Diversion Effects on Fish

Issues and Impacts

Prepared by the

CALFED Diversion Effects on Fish Team

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CALFED
BAY-DELTA
PROGRAM

EXECUTIVE OVERVIEW

An interagency/stakeholder Diversion Effects on Fish Team (DEFT) was formed to address the technical issues related to diversion impacts on fisheries for each the CALFED alternatives. The primary issues addressed were:

- Which species, populations, and life stages are most sensitive to diversion effects under no action and alternatives 1, 2, and 3?
- What degree of benefit and impact will the common programs provide?
- What is the risk and chances of success of species recovery for each alternative?

To evaluate these issues, species teams were formed for salmon, striped bass, and delta smelt. These species were chosen because they represent a range of exposure periods and they are the objects of numerous management and regulatory concerns. There are species that may be affected by changes in delta conditions whose responses may differ from the species analyzed here. The species teams developed matrixes on the effects of a set of impact parameters on the life stages of each species by month for each alternative. The detailed matrixes are described in individual species reports appended, which the reader is strongly urged to review for the details of the evaluations. This report summaries the process, assumptions, modeling studies, information used, professional judgement and the conclusions reached by the teams.

This report and the results should be interpreted cautiously, recognizing the many informational and procedural limitations inherent in these work products. The short time frame provided for this work compelled the team to rely primarily on professional judgement to evaluate the degree to which each relevant factor affects each of the key species. Assumptions had to made that in some cases limited the teams ability to answer the primary issues and included: 1) evaluation of diversion effects on fish populations was confined to the legally defined Delta, Suisun Bay and Suisun Marsh, even thought the CALFED solution area is much larger; 2) evaluations were based on a single operations study for each scenario with no attempt to minimize impacts or maximize benefits, (The next phase of the teams efforts will be to optimize the alternatives.), 3) the common programs will provide benefits with some negative impacts to each of the evaluated species, but the quantification of these benefits is uncertain, and 4) the impacts of water quality and exotics issues have not been evaluated.

The following were consensus professional judgements of the species teams, based on system operations modeling studies and published and unpublished information on individual species biology. Although the team had consensus on a number of assumptions regarding delta species biology, opinions of other scientists on the validity of the assumptions will likely vary from consensus to strong disagreement. The outcome of the assessments is very dependent on these assumptions.

The **salmon** team evaluated relative survival in the Delta of chinook salmon from the Sacramento and San Joaquin basins; Sacramento River races were assessed in aggregate. Survival was estimated monthly in relation to impact parameters considered important to salmon survival in the Delta. For Sacramento River chinook, five composite parameters had the greatest

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effects on survival; 1) entrainment losses, 2) flows below a Hood diversion, 3) interior-Delta survival, 4) habitat restoration, food supply, and screening of small agricultural diversions, and 5) impacts on adult upstream migration. Common Programs, Alternative 1, and Alternative 3 had similar total impacts, but involved different tradeoffs among benefits and detriments to salmon survival. Alternative 2 was least favorable, largely due to anticipated increases in adult straying and migration delays. For all three Alternatives, Common Programs provided most of the benefit. For San Joaquin salmon, the key composite parameters were 1) entrainment losses, 2) flow at Vernalis, 3) interior-Delta survival, and 4) habitat restoration, food supply, and screening of small agricultural diversions. Alternative 3 offers the greatest benefits for San Joaquin salmon, exceeding the benefits of any alternative for Sacramento salmon. Benefits accrue through reduced entrainment and improved interior-Delta survival.

The **striped bass** team concluded that none of the alternatives are likely to restore the adult population to historic levels (i.e., population of 1.8-3 million). Alternative 3 provides the best potential for partial restoration of the population. Alternative 3 is likely to reduce the entrainment of juveniles at the south Delta export facilities and increase the salvage of those that are entrained. Alternative 3 will likely enhance the transport of eggs and larvae in the lower San Joaquin River by positive flows and also restore Delta nursery habitat. However, both Alternatives 2 and 3 may have negative impacts by decreasing egg and larva transport below the Hood intake. Alternative 2 also has high impacts because of passage problems created for adult fish using the Mokelumne River as a migration route to Sacramento River spawning grounds. Alternative 2 also subjects eggs and larvae to two diversion points. Alternative 1 is likely to increase the entrainment of eggs and larvae at the south Delta export facilities. The common programs have both potential benefits and detriments that were difficult to quantify but are likely to have some net benefit.

The **delta smelt** team concluded that Alternative 3 has the most potential to improve conditions for delta smelt; however, the uncertainty associated with this evaluation is extremely high. The delta smelt team made separate evaluations for wet years and dry years. The No Action Alternative results in a slight worsening of conditions in both year types because of increased diversions to meet increased demand. The Common Programs result in a moderate improvement in conditions in both year types because of hypothesized benefits associated with increases in shallow-water habitat. Alternatives 1 and 2 represented moderate improvements compared to existing conditions but the benefits are derived from the Common Programs rather than changes in conveyance associated with the alternatives. Alternative 1 resulted in a slight decline in value in relation to the Common Programs. Alternative 2 resulted in a moderate decline in the value in relation to the Common Programs. The hydrodynamic effects of Alternative 2 were believed to be a strong negative effect on delta smelt. Alternative 3 resulted in significant benefit to delta smelt because of the combination of the positive effects of the Common Programs and the Team's assessment that the hydrodynamic effects would also be positive for the majority of the population. The degree of benefit from the three Alternatives is very dependent on the Common Programs; thus, different assumptions about benefits of the Common Programs could result in substantially different assessments.

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1. INTRODUCTION

An interagency/stakeholder Diversion Effects on Fish Team (DEFT) was formed to addressed the technical issues related to diversion impacts on fisheries for each the CALFED alternatives. The primary issues addressed were:

- Which species, populations, and life stages are most sensitive to diversion effects under no action and alternatives 1, 2, and 3? When and where are they most affected?
- What degree of benefit and impact will the common programs provide?
- What is the risk and chances of success of species recovery for each alternative?

To provide a base to evaluate the these issues, interagency/stakeholder species sub-teams were formed for salmon, striped Bass, and delta smelt. This report summaries the organization, process, assumptions, modeling studies, information used, professional judgement and the conclusions reached by these species teams and the full DEFT.

Team Organization

Members of the DEFT are listed below under the species team on which they primarily served. Some participated in several teams. Several people contributed to the species teams that are not on the DEFT. They are identified with an (*).

Salmon team
Patricia Brandes (co-chair), U.S. Fish and Wildlife Service
Shelia Greene (co-chair), Department of Water Resources
Serge Birk, Central Valley Project Water Association
Pete Chadwick, Department of Fish and Game
Karl Halupka, U.S. National Marine Fisheries Service
Jim White, Department of Fish and Game
*Jim Starr, Department of Fish and Game
Striped Bass Team
Lee Miller (chair), Department of Fish and Game
Elise Holland, Bay Institute
*Stephani Spaar, Department of Water Resources
*David Kohlhorst, Department of Fish and Game
Kevan Urquhart, Department of Fish and Game
*Don Stevens, Department of Fish and Game
Delta Smelt Team
Dale Sweetnam (co-chair), Department of Fish and Game
Larry Brown (co-chair), U.S. Bureau of Reclamation
Michael Thabault, U.S. Fish and Wildlife Service
*Chuck Hanson, State Water Contractors

<u>*DEFT members not on a specific species team*</u>
Bruce Herbold, U.S. Environmental Protection Agency
Pete Rhoads, Metropolitan Water District Southern California
Michael Fris, U.S. Fish and Wildlife Service
Jim Buell, Metropolitan Water District Southern California
Ron Ott, CALFED

Process

To guide the species teams and to provide a framework for addressing the issues the DEFT developed a list of impact parameters that have direct and indirect effects on the populations in the Delta. Each species team modified the impact parameters listed below to better assess the impacts on their particular specie. The general impact variables are:
- Entrainment
- Hydrodynamics
- Predation
- Handing
- Food Supply
- Shallow/near shore Habitat
- Water Quality (Contaminants)
- Water Quality (Temperature)
- Water Quality (Salinity)
- Agriculture Diversions
- Straying

Each species team evaluated the impacts and benefits on their species against the above parameters for each month of the year for:
- Exiting Conditions
- No Action
- Common Programs
- Alternative 1
- Alternative 2
- Alternative 3

These alternatives are described in the CALFED document, "Programmatic EIS/EIR, Technical Appendix-Phase II Report", March 1998
Sacramento and San Joaquin salmon represent anadromous species with the shortest exposures to delta conditions. Striped bass, an anadromous species, and delta smelt, a resident species, represent species with greater exposure to delta conditions.

The species teams developed matrixes on the effects of the impact parameters on the life stages of each species by month for each alternative. These were used by the teams to address the primary listed above and other issues listed below. The detailed matrixes and interpretations are described in individual species reports in Appendices 1,2 & 3. Species teams reports were review by the DEFT and other stakeholders outside the DEFT.

Other Issues

This report focuses on primary issues 1, 7, and 5. In addressing these three primary issues the species teams also answered several other issues, numbered below. All others except issues 4 and 13 were addressed in the individual species report (Appendices 1,2&3). Issues 4 and 13 will be addressed in the next phase of this teams efforts. The issues are:

1. Which species, populations, and life stages are most sensitive to diversion effects under no action and alternatives 1, 2, and 3? When and where are they most affected?
2. Can diversion effects in the South Delta be offset by habitat improvements and other common program actions?
3. To what extent can alternatives 1, 2, and 3 offset diversions effects as presently configured?
4. To what extent can diversion effects be offset by modifications to the alternatives or by operational changes? (Will be addressed in biological operation criteria white paper.)
5. What is the risk and chances of success of species recovery for each alternative?
6. What increment of protection or improvement for fish species will be provided by other programs such as the Central Valley Project Improvement Act, biological opinions, etc.?
7. What degree of benefit and impact will the common programs provide?
8. What are the direct and indirect effects on fish populations resulting from each alternative and what is the expected response of the populations to these effects?
9. What Sacramento River flow is required below a Hood diversion to protect salmon, striped bass and delta smelt?
10. What survival rate can be expected for striped bass eggs and larvae and delta smelt passing through Sacramento River screen and pumps in Alternative 2?
11. Should there be a screen on the Sacramento River intake of Alternative 2?
12. What are the logical stages for a preferred alternative? (Will be address in biological operation criteria white paper.)
13. What is the range of biological criteria that should be considered in operations of the three alternatives? (Will be addressed in biological operation criteria white paper.)

2. ASSUMPTIONS AND LIMITATIONS

This report and the results should be interpreted cautiously, recognizing the many informational and procedural limitations inherent in these work products. The short time frame provided for this work compelled the team to rely primarily on professional judgement to evaluate the degree to which each relevant factor affects each of the key species. Assumptions had to made that in some cases limited the teams ability to answer the primary issues. The assumptions and limitations are summarized below.

Biological Scope

The team has analyzed the impacts of different CALFED scenarios using the three species that represent types of fish likely to be affected. Some species, such as those that live their entire lives upstream or downstream of the delta are unlikely to be affected by changes in point of diversion in the delta. Other species, such as tule perch or largemouth bass, have life history characteristics that make them much less sensitive to hydrodynamic conditions or entrainment were also excluded. The three species the team examined included Sacramento and San Joaquin salmon to represent anadromous species with the shortest exposure to delta conditions. Striped bass, an anadromous species, and delta smelt, a resident species, represent species with greater exposure to delta conditions. Other species that may be affected by changes in delta conditions, but whose responses may differ from the species analyzed here, include: green sturgeon, white sturgeon, longfin smelt, Sacramento splittail, and American shad. CALFED may need to develop a future analysis to address these species.

Geographic Scope

The geographic scope of the CALFED "solution area" encompasses all of the Central Valley, San Pablo and San Francisco bays, and the near-shore Pacific ocean. The team's evaluation of diversion effects on fish populations was confined to the legally defined Delta, Suisun Bay and Suisun Marsh. Consequently, the team did not incorporate into its evaluation the potential beneficial and adverse effects of actions outside that area. Fluctuations in ocean and bay conditions, salmon and striped bass harvest management, CALFED's Ecosystem Restoration and Water Quality programs that occur outside the delta, and actions associated with the Central Valley Project Improvement Act (CVPIA) are all likely to affect fish populations.

Restoration and recovery of these three species will also depend on CALFED actions outside of the "problem identification area" that the team has addressed. CALFED's actions must also address many issues of greater uncertainty than those addressed, such as offshore harvest. Therefore, the team was unable to assess the degree to which the effects of these delta-based scenarios contribute to overall restoration and recovery. A far more complex and time-consuming analysis would be necessary to integrate the Delta effects we identify, with the broader range of natural fluctuations and human activities that will determine recovery.

The team identified the principal mechanisms by which storage and conveyance will affect these species, when these species are in the Delta. The team assigned relative ranks to summarize it's assessments of the balance of impacts and benefits for each scenario.

Process

Evaluations were based on the team's best professional judgement to the degree of which each relevant parameter affects each key species. The judgements considered empirical relationships between parameters and survival, where such relationships were available. Evaluations were based on operations modeling studies and qualitative assessments of the degree to which water operations, water management facilities, and biological parameters affect the populations of each species. More rigorous quantitative analysis was not possible within the time constraints imposed on this process.

The evaluations recognized the many sources of uncertainty that derive from the limitations of our scientific knowledge about the species and Bay-Delta ecosystem. From an analytical perspective, monthly averaged hydrology was the primary hydrologic parameter used in the analysis. For example, the use of particle tracking model output, which is based on short time-steps, may help reduce this uncertainty.

Sources of uncertainty on biological processes takes a variety of forms and makes any predictions of actual results at the population level extremely problematic. For example, the benefits of shallow water habitat to Delta smelt are not yet well understood. With regard to striped bass, the continuation of historic relationships into the future is unclear due to the many changes in the system. For salmon, the sources of mortality in the Delta are poorly understood. The various sources of uncertainty were acknowledged, identified, and considered to the extent possible in the evaluation

Procedures and Inputs

Evaluations are based on a single operations study for each scenario. There has been no attempt to minimize impacts or maximize benefits. The next phase of the teams efforts will be to optimize the alternatives. The specific CALFED operations studies used for each scenario were: Existing Conditions-558, NoAction-516, Alternative 1 without storage-518, Alternative 1 with storage-609, Alternative 2 without storage-528, Alternative 2 with storage-532a, Alternative 3 without storage-595, and Alternative 3 with storage-567. These runs included meeting the flow requirements for the Vernalis Adaptive Management Plan (VAMP), meeting the 1995 WQCP, and the biological opinions for delta smelt and winter-run chinook salmon. Analyses were based on monthly flows at selected locations in the Delta averaged over all years and averaged over selected dry and critical years. No attempt was made to explore the full range of annual variability

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Using the model runs above, each alternative was analyzed by the salmon team with no new storage and with maximum new storage. The delta smelt and striped bass teams analyzed the no new storage alternatives only. The range of storage represents the extremes of existing storage to an additional 6.2 MAF of new storage. Storage between these two extremes would have marked results on the outcome of these evaluations. There was no attempt to minimize impacts or maximize benefits by optimizing storage.

For each alternative, the model runs produced average monthly flows at locations throughout the Delta. Wet and dry year flow summaries were used in the evaluation of impacts of an alternative. In some cases , using average monthly flows and monthly summaries could minimize the actual impacts or benefits of an alternative. The team attempted to account for the model limitations in their evaluations.

Incorporation of Common Programs

The evaluation of the effects of the Common Programs posed particular challenges for this evaluation. For example, at the current programmatic level of development, the distribution of restored/rehabilitated wetland and riparian habitat has not been defined. Different distributions of habitat would benefit different species. However, even if the distribution were clearly defined, our current level of scientific knowledge limits the evaluation of the benefits that would accrue to each species.

There was a broad consensus among the team that the common programs will provide benefits to each of the evaluated species. The quantification of these benefits is, however, not possible at this time. Increasing the amount of habitat will almost certainly increase the potential for survival of each of the evaluated species, but the magnitude of the increase is uncertain. Some potential impacts of the water quality program on striped bass are considered.

Water Quality

Changes in point of diversion would effect a variety of water quality parameters in the Delta. San Joaquin River water carries a significant load of agricultural chemicals, selenium, and other contaminants and nutrients. Sacramento River water generally carries lower loads and carries different metals such as copper, mercury, cadmium and zinc. Delta water directly receives a variety of agricultural chemicals (including herbicides), salts and organic carbon. Contaminant loads and concentrations vary seasonally, vary with hydrology, and can be expected to vary with different points of diversion and changes in operating criteria. The availability and effects of these chemicals on fish populations, and the food web that supports them, are unknown but potentially significant. Impacts may occur through direct toxicity, but are more likely through chronic effects or trophic disruptions. Synergisms of chronic effects with other factors such as disease or reduced growth that prolongs exposure to predators may also result in effects on fish populations. Changes in the point of diversion could also affect the transport of ocean derived salts in the Delta. The DEFT has not attempted to incorporate any of these contaminant effects into the evaluations of fishery impacts , and recommends collaborative efforts of the ecosystem restoration and water quality program elements to address these concerns as part of the plan for implementing the first phase of the CALFED program. A small group of appropriate experts from the water quality team and the DEFT should meet to evaluate these factors and help the DEFT revise the present report.

Exotics

The Bay/Delta is dominated by non-native species. Some introduced species have substantially altered the functioning of ecosystems they have invaded and the team has limited understanding of the new ecological relationships among species. New species will likely continue to arrive and disrupt the biological communities of the estuary in the future. All data and analyses, therefore, that rely on historical relationships may not predict the future but they are the only available basis for analysis. The almost certain arrival of new species in the future may alter the ability of the estuary to support these three species but the group feels it is unlikely that effects of new species introductions would change the performance of the alternatives relative to each other ,in that, species introductions would not fundamentally alter the response of a fish population to basic ecosystem properties such as spawning habitat, streamflow, or hydrodynamics.

3. PRIMARY QUESTIONS

Each of the species team addressed the primary and other issues in their species reports in Appendices 1, 2 and 3. Summary evaluations of the primary questions (1, 7, and 5) for each species follow.

Salmon

1) Which species, populations, and life stages are most sensitive to diversion effects under existing conditions No Action and Alternatives 1, 2, and 3? When and where are they most affected?

The salmon Team evaluated diversion effects in the Delta on San Joaquin basin chinook salmon and an aggregate of all races of Sacramento-basin chinook. All San Joaquin chinook migrate through the south Delta, where they experience direct entrainment, loss in Clifton Court Forebay, and reduced survival associated with unfavorable flow distributions. A much smaller portion of Sacramento chinook are affected by diversions from the south Delta.

Substantial negative effects exist for both groups under existing conditions, and those would persist under No Action and Alternative 1, although direct entrainment losses would be reduced by a small increment under Alternative 1. Under Alternatives 2 and 3, the entire population of Sacramento chinook would emigrate past a screened diversion at Hood, and would be exposed to flow reductions in the Sacramento River downstream of Hood. Adverse effects unique to Alternative 2 would be increased straying and migratory delay of adult salmon returning to the Sacramento basin, due to both attraction to the Mokelumne River portion of the Delta and exposure to a fish passage facility at the Hood diversion. Under Alternative 2, direct and indirect effects in the San Joaquin portion of the Delta would be less for salmon from both rivers. Those effects would be further reduced under Alternative 3.

Fry rearing in the Delta is important to salmon production, especially in wet years. Diversion effects are believed to be greater on actively migrating yearlings and smolts, whether rearing takes place in the Delta or in upstream areas.

7) What degree of benefit and impact will the Common Programs provide?

Much of the expected benefit for salmon would result from restoration of shallow water habitat. However, the actual effect on salmon populations is uncertain. Salmon pre-smolts are particularly likely to use restored habitats. Restored habitats would also be favorable for predators but in the opinion of most salmon biologists the increased cover and food supply should increase salmon survival and provide net benefits. If habitat restoration is successfully implemented along migration corridors for salmon, benefits should be greater than estimated in this analysis. Screening Delta diversions and improved Delta water quality are also expected to be beneficial. Increased spring flows would slightly improve chinook survival in the Delta, in addition to providing upstream benefits. The Water Use Efficiency and Water Transfer programs would increase flexibility in water supply operations, offering some opportunities to shift diversions to times less detrimental to salmon, but such shifts would probably increase impacts on other species. Overall, the Common Programs are unlikely to provide sufficient benefits in the Delta to offset diversion effects fully.

5) What are the risks and chances of success of species recovery for each alternative?

Recovery depends on conditions throughout the life history of salmon. Because the salmon team considered only needs of juveniles and adults in the Delta, the following answers are more appropriate for addressing risks of precluding recovery by significantly adversely impacting one lifestage, rather than addressing the chances of success of species recovery.

No Action - Substantial adverse impacts to San Joaquin chinook in the south Delta under Existing Conditions would increase under No Action due to the increased exports from the south Delta. Although a smaller proportion of the Sacramento chinook are impacted by south Delta exports, substantial negative effects exist for both groups under existing conditions, and those would persist under No Action. The operation studies provided for these analyses assume the Delta Cross Channel gates are closed between November and June to improve survival of salmon migrating down the Sacramento River. The validity of this assumption during November and December was questioned by the salmon team since water quality objectives often are in conflict during low flow periods. The ongoing efforts of the Ops Group to improve salmon survival under Existing Conditions in the face of limited operational flexibility, and the probable decrease in flexibility over time with the No Action scenario, indicate potential for precluding recovery.

Alternative 1- Delta Cross Channel gate closure to improve survival of salmon emigrating down the Sacramento River would continue to be in conflict with water quality objectives during low flow periods. Improved fish screens in the south Delta would provide additional protection, especially for San Joaquin salmon. These benefits would be tempered by the continued need for handling and trucking, but this is less of a risk for salmon than for many other species. Overall, reduced entrainment and benefits from the Common Programs probably would not be sufficient to cause major improvements in salmon production.

Alternative 2- The diversion at Hood would impose several new risks for salmon from the Sacramento system (see response to question 1 above). The salmon team believes that Alternative 2 would pose risks for salmon from the Sacramento system greater than any other alternative, potentially resulting in population declines relative to Existing Conditions. For salmon from the San Joaquin, the combination of improved flow distribution in the central Delta, and benefits from new screens in the south Delta (see Alternative 1), would make Alternative 2 superior to Alternative 1.

Alternative 3- For Sacramento salmon, Alternative 3 would not pose the same risk for upstream migrants as Alternative 2. Other risks of the Hood diversion would be essentially the same as those described for Alternative 2. These risks would result in overall benefits about the same as for the Common Programs. San Joaquin basin chinook have the greatest potential to benefit from Alternative 3. The benefit that would be most certain is the reduction in entrainment losses associated with the large reduction in diversions from the south Delta.

Striped Bass

1) Which species, populations, and life stages are most sensitive to diversion effects under existing conditions No Action and Alternatives 1, 2, and 3? When and where are they most affected?

No Action- Striped bass eggs, larvae, and juveniles are directly impacted by water diversions in the Delta during the first year of life from April through fall, and sometimes during winter. The impact on eggs and young fish occurs from April to July, with further impacts on larger juveniles through summer and fall. Under current conditions, the population is likely to continue to decline in the absence of a stocking program. In recent years, young striped bass abundance has remained low despite higher-than-average delta outflows and low export rates, both of which are conducive to strong year classes in the past.

Alternative 1- Entrainment of eggs, larvae, and juveniles in the south Delta will continue and increase with channel improvements and additional storage. Closure of the cross channel gates through the spawning season from April to June would reduce the diversion of Sacramento River striped bass eggs and larvae but may cause increased flow reversal in the lower San Joaquin River.

Alternative 2- Increased numbers of eggs and larvae could be diverted and entrained from the Sacramento River because fish screens at the Hood diversion would be inadequate to screen these stages. The magnitude of diversion of eggs and larvae from both the Sacramento and San Joaquin rivers, as well as juveniles from the San Joaquin, depends on operation of the facilities. For example, temporary reduction in diversion at Hood during the striped bass spawning season would reduce diversion of eggs and larva from the Sacramento River and provide transport flow to move young bass to the nursery areas downstream. At the Clifton Court diversion, eggs, larvae, and juveniles would be continue to be entrained; more juveniles would be salvaged.

Adults would be attracted by the high proportion of Sacramento water in the Mokelumne River and they would be trapped behind the fish screen at Hood. The feasibility of passing large numbers of striped bass around or over such structures is highly questionable. Adults trapped behind the Hood fish screen would be forced to spawn in the Mokelumne River and most of their progeny would be entrained in the flow to the export pumps. If flow diverted at Hood is a large proportion of the Sacramento flow, as might occur in dry years, more fish would be attracted to the Mokelumne as a corridor to the spawning grounds.

Alternative 3- Increased numbers of eggs and larvae could be diverted and entrained from the Sacramento River because fish screens at the Hood diversion would be inadequate to screen these stages. The magnitude of diversion of eggs and larvae from both the Sacramento and San Joaquin rivers, as well as juveniles from the San Joaquin, depends on operation of the facilities. For example, temporary reduction in diversion at Hood during the striped bass spawning season would reduce diversion of eggs and larva from the Sacramento River and provide transport flow to move young bass to the nursery areas downstream. If diversions are not curtailed entrainment of egg and larva will be high and transport flows will likely be inadequate. Adult migrations would not be affected as for Alternative 2 because the facility is isolated. Because QWEST flows would be improved over existing conditions and less water would be diverted from the south Delta, the team expects less entrainment of striped bass and improvement of nursery habitat in the Delta.

7) What degree of benefit and impact will the Common Programs provide?

The common programs will likely provide some benefits to young striped bass, but these are difficult to quantify. Screening of small Agricultural diversions would reduce mortality of young striped bass. Increasing the amount of marsh habitat for nursery areas adjacent to Suisun Bay and in San Pablo Bay would likely increase survival of young striped bass. Reducing point and non-point sources of toxic chemicals and metals could improve conditions for all life stages to some degree; however, present population impacts of toxicants have not been demonstrated. Reduction of organic input and decreasing turbidity may adversely affect striped bass production.

5) What are the risks and chances of success of species recovery for each alternative?

When and where are they most affected? The adult population is affected by reduced recruitment as a result of early life stage losses. Although there is evidence of density-dependent survival (compensation) it has not been sufficient to maintain the numbers of adults that were historically present. Recovery cannot occur under the No Action Alternative. Alternatives 1 and 2 appear to exacerbate present problems associated with using the Delta as a water export conduit. Alternative 3, while falling short of restoration to historic population levels, would, if operated in a manner which minimized entrainment of young striped bass and provided adequate transport flows, provide the best opportunity for partial restoration of the population.

Delta Smelt

1) Which species, populations, and life stages are most sensitive to diversion effects under existing conditions No Action and Alternatives 1, 2, and 3? When and where are they most affected?

No Action: Larvae and young juveniles are the most sensitive life stages. These life stages are present in the spring and early summer. The major effects occur in the central and south Delta where altered hydrodynamics and entrainment are important. As delta smelt become adults, they migrate downstream to brackish water areas in the fall and winter and are considered less vulnerable to diversion effects. Pre-spawning adults migrating back into freshwater to spawn in the late winter and early spring become vulnerable to entrainment effects once again.

Alternative 1: The same as No Action.

Alternative 2: Larvae and young juveniles are still the most sensitive stages and are still vulnerable at the same times. The major changes in hydrodynamics anticipated with Alternative 2 are believed to be a negative factor for all life stages of delta smelt, but especially these sensitive stages. These negative effects are expected to be most severe in the eastern Delta.

Alternative 3: Alternative 3 was given high benefit because of its positive effects on returning Delta hydrodynamics to a more "natural" condition, meaning the rivers and most channels maintain positive outflows at most times and places. Positive benefits for delta smelt may be high compared to other species because it is the only species to complete its entire life cycle in the estuary.

7. What degree of benefit and impact will the common programs provide?
The delta smelt team estimated that improvement would occur with the common programs. Much of the benefit predicted is due to the creation of additional shallow water habitat of several different types. The effect on delta smelt is uncertain. Much of this uncertainty stems from the scarcity of evidence of the effects of increasing such habitat. Delta smelt use such habitat for spawning but it seems to be of no special importance as rearing habitat. There is no evidence that spawning habitat is a limiting factor for the delta smelt population. While the habitat will also be favorable for predators, the increased spawning habitat and possible increases in Delta primary productivity and food supply were believed to be possible benefits and were assigned benefits even though this is an area of high uncertainty. Screening Delta diversions and improved Delta water quality are also expected to be beneficial.

5. What is the risk and chances of success of species recovery for each alternative?
For the delta smelt team recovery is defined in "The Recovery Plan for the Sacramento/San Joaquin Delta Native Fishes" (Appendix 1). Alternative 1 is not a major change and probably has little influence on probability of recovery. Alternative 2 seems likely to negatively affect probability of recovery. Alternative 3 seems likely to improve the probability of recovery. All of these assessments are subject to the uncertainties already identified above.

4. SUMMARY MATRIX

The reader is strongly urged to read the detailed species reports in the Appendices for the details of the evaluations. In these reports each species teams developed rational and matrixes that scored the effects of the impact parameters on the life stages of each species by month for each alternative. In that process each team used an evaluation scoring scale referenced to a baseline that allowed that team to make relative evaluations between the alternatives for that species. Some set baseline at existing conditions with a score of "0" while others set baseline to pre-water project conditions. These scales were used by the teams to assist in addressing the primary and other issues. The teams did not try to achieve complete comparability in the baselines and scoring of the various species. For this summary report the team's adjusted the scores so that "0" , the baseline, in all cases is existing conditions and +7 is approaching full restoration. A minus score indicates that the alternative is worse than the existing conditions for the particular species. In general, the scores may be further subdivided as follows:

-3 to -1 = decreases in abundance likely (opposite effect of program goals)
0 = abundance is likely to be similar to existing conditions
+1 to +2 = small increases in abundance at best (unlikely to achieve program goals)
+3 to +5 = increase in abundance likely (may achieve program goals)
+6 to +7 = high likelihood that goals of restoration and recovery may be achieved.

Two types of general uncertainty were associated with the evaluation: 1)uncertainty associated with the existing conditions and causes of impacts on the species, and 2)uncertainty associated with the predicted benefits and impacts of the alternatives. Both types were integrated in the uncertainty scores in the tables below. For existing conditions the salmon team felt the causes of impacts on salmon species are well known and the uncertainty scores do not apply. The salmon team also recognized that considerable exists as to causes, but chose to reflect only uncertainty in predicted benefits and impacts in assigning uncertainty scores.

The integrated levels of uncertainty associated with the scores were assigned:

1 = Low uncertainty
2 = Moderate uncertainty
3 = High uncertainty

The following summary matrices show the score for improvement of the species, the uncertainty associated with the score, and a highlight of the benefit or impact for each alternative.

Salmon

Alternatives	**Sacramento River Salmon**	**San Joaquin River Salmon**
Existing Conditions	Score: 0 Uncertainty: NA - Interior-Delta survival is low. - Entrainment losses, suboptimal flow below Hood, and losses to Delta agricultural diversions.	Score: 0 Uncertainty: NA -Detriments associated with low interior-Delta survival, insufficient Vernalis flows, and high entrainment losses.
No Action	Score: 0 Uncertainty: 1 - Minor additional detriments did not warrant a change in summary score.	Score: 0 Uncertainty: 1 -Minor additional detriments did not warrant a change in summary score.
Common Programs	Score: +2 Uncertainty: 2 - Improvement would be driven by both increased shallow water habitat (shelter and reduced predation), and improved food supply. - Improved flows and reduction in agricultural-diversion losses also would contribute to improvement.	Score: +1 Uncertainty: 2 - Improvement would be driven by both increased shallow water habitat (shelter and reduced predation), and improved food supply. - Improved flows and reduction in agricultural-diversion losses also would contribute to improvement.
Alternative 1	Score: +2 Uncertainty: 2 - Benefits derived from Common Programs. - Insufficient change from Common Programs to warrant a change in summary score. - Small reduction in entrainment losses.	Score: +2 Uncertainty: 2 - Improved screens in the south Delta would provide a substantial benefit.
With new storage	Score: +1 Uncertainty: 2 - Reduced flow associated with storage considered sufficient to diminish Interior-Delta survival and increased entrainment losses reduce summary score for this option.	Score: +1 Uncertainty: 2 - Increased exports would contribute to increased entrainment and reduced interior-Delta survival. - Improved screens in the south Delta would provide a substantial benefit.
Alternative 2	Score: -1 Uncertainty: 3 - Interior-Delta survival would be improved. - Improvement would be outweighed by reduced flows below Hood, juvenile entrainment losses at the Hood screen, and the barrier to adult upstream migration (increased straying and delayed migration).	Score: +3 Uncertainty: 3 - Improved flow distribution in the interior Delta would increase survival. - Improved screens in the south Delta would provide a substantial benefit.

Alternatives	**Sacramento River Salmon**	**San Joaquin River Salmon**
With new storage	Score: -2 Uncertainty: 3 - Reduced flow associated with storage considered sufficient to diminish Interior-Delta Survival and increased entrainment losses reduce summary score for this option.	Score: +2 Uncertainty: 3 - Similar adverse effects as in Alternative 1. - Improved screens in the south Delta would provide a substantial benefit.
Alternative 3	Score: +2 Uncertainty: 3 - Interior-Delta survival would be improved. - Improvement would be outweighed by reduced flows below Hood and juvenile entrainment losses at the Hood screen. - Tradeoff between beneficial and adverse effects yields the same summary score as for Common Programs.	Score: +4 Uncertainty: 2 - Anticipated ~80% reduction in south-Delta exports would reduce entrainment losses and further improve interior-Delta survival. - Improved screens in the south Delta would provide a substantial benefit.
With new storage	Score: +2 Uncertainty: 3 - Minor additional detriments did not warrant a change in summary score.	Score: +4 Uncertainty: 2 - Minor additional detriments did not warrant a change in summary score. - Improved screens in the south Delta would provide a substantial benefit.

Striped Bass

Alternatives	**Striped Bass**
Existing Conditions	Score: 0 Uncertainty: NA • Major entrainment of young life stages
No Action	Score: -1 Uncertainty: 3 • Major entrainment of young life stages
Common Programs	Score: +1 Uncertainty: 3 • Uncertain benefits of habitat improvements • Uncertain benefits/detriments of water quality improvements • In-Delta screening benefits juveniles
Alternative 1	Score: +1 Uncertainty: 3 • Increased entrainment of young life stages over existing conditions • Decreased mortality of entrained juveniles • QWEST not improved

Alternatives	**Striped Bass**
Alternative 2	Score: 0 Uncertainty: 3 • Potential increased entrainment of eggs & larvae (north and south Delta) • Transport flows for eggs and larvae possibly decreased and mortality increased • Decreased mortality of entrained juveniles • Improved QWEST • Adult passage problems and detrimental change in spawning location
Alternative 3	Score: +3 Uncertainty: 3 • Potential increased entrainment of eggs & larvae at Hood • Reduced entrainment of eggs, larvae and juveniles from the Delta • Transport flows for eggs and larvae possibly decreased and mortality increased unless strategic curtailments implemented. • Improved QWEST and Delta nursery habitat.

Delta Smelt

	Delta Smelt -Water Year Type	
Alternative	Wet	Dry
Existing Conditions [1]	Score: 0 Uncertainty: 2 - Baseline condition	Score: 0 Uncertainty: 2 - Baseline condition
No Action	Score: -1[2] Uncertainty: 3 - Negative effect because of increased diversion to meet increasing demand.	Score: -1 Uncertainty: 3 - Negative effect because of increased diversion to meet increasing demand.
Common Programs	Score: +2 Uncertainty: 3 - Positive benefit is hypothesized for increased shallow-water habitat. - Positive benefit is hypothesized for consolidation and screening of agricultural diversions.	Score: +2 Uncertainty: 3 - Positive benefit is hypothesized for increased shallow-water habitat. - Positive benefit is hypothesized for consolidation and screening of agricultural diversions.
Alternative 1	Score: +1 Uncertainty: 3 - The Common Programs provide the only positive benefit.	Score: +2 Uncertainty: 3 - The Common Programs provide the only positive benefit.
Alternative 2	Score: +1 Uncertainty: 3 - The Common Programs provide the only positive benefit. - The changes in conveyance and resulting hydrodynamics will negatively effect all life stages.	Score: +1 Uncertainty: 3 - The Common Programs provide the only positive benefit. - The changes in conveyance and resulting hydrodynamics will negatively effect all life stages.

	Delta Smelt -Water Year Type	
Alternative	Wet	Dry
Alternative 3	Score: +4 Uncertainty: 3 - Positive benefits of Common Programs. - Reduced entrainment. - Improved hydrodynamics.	Score: +5 Uncertainty: 3 - Positive benefits of Common Programs. - Reduced entrainment. - Improved hydrodynamics.

[1] Existing conditions for wet and dry conditions are not the same. Existing conditions for dry years are worse than for wet conditions. Do not compare across the columns.

[2] The negative effect for both year types is actually less than a full unit. The -1 simply implies a slight negative effect, in this case only.

DIVERSION EFFECTS ON FISH

APPENDIX A

CALFED ALTERNATIVE EVALUATION FOR CENTRAL VALLEY SALMON SURVIVAL WITHIN THE DELTA

DIVERSION EFFECTS ON FISH

CALFED ALTERNATIVE EVALUATION FOR
CENTRAL VALLEY SALMON SURVIVAL WITHIN THE DELTA
NARRATIVE

Draft - June 23, 1998

In this report, we describe an analysis of diversion effects on Central Valley chinook salmon within the Delta. Our assignment was to evaluate variations in the survival of chinook salmon within the Delta for each of several scenarios being considered in the CALFED Program. The scenarios are No Action, Common Programs and Alternatives 1, 2, and 3, and are evaluated in relation to Existing Conditions. Our evaluation is based on one operation study for each scenario. Because variations in operations could result in considerable differences in effects on chinook salmon within the Delta, our analysis provides only a first approximation of potential differences among scenarios.

We evaluated the effects of CALFED water storage and conveyance alternatives on chinook lifestages in the Delta; we did not evaluate overall effects on chinook population dynamics. An analysis of survival throughout the entire Sacramento and San Joaquin basins, in the Delta and Bay, and in the ocean would be necessary to assess the effects of the CALFED program on overall chinook population dynamics. Evaluation of effects on survival upstream from the Delta would be particularly important for the CALFED Ecosystem Restoration and Water Quality Programs. Evaluation of effects of ocean conditions and commercial and recreational harvests would be important to provide an appropriate perspective on impacts in the ocean. Although our within-Delta analysis is not sufficient to evaluate the effects of the entire CALFED program, it is sufficient to describe the full effects of the alternative ways of transferring water across the Delta being considered in the CALFED Programmatic Environmental Impact Statement.

We prepared separate analyses for chinook salmon from the Sacramento and San Joaquin systems, because of their different uses of the estuary. From the San Joaquin system, only one race, fall run, is involved. From the Sacramento system, four races are involved, each juvenile lifestage using the estuary to a different extent and during a distinctive time period, collectively using the estuary in every month except July. (In August, estuary use is limited to adults immigrating upstream, and the subcommittee identified no adverse effects.)

Two of the races, the Sacramento winter and spring runs, are receiving protection under endangered species laws and thus require special consideration in making management decisions. At this stage, the subcommittee's analysis integrates effects over all runs, without separately identifying effects on the listed runs.

We first analyzed the effects (by month) of parameters expected to influence salmon survival in the Delta. We used the results of this analysis to answer a series of questions posed by CALFED. This report includes both a description of our analysis and answers to CALFED's questions.

The subcommittee is co-chaired by Patricia Brandes, U. S. Fish and Wildlife Service and Sheila Greene, Department of Water Resources. Other biologists participating fully throughout the analysis were Serge Birk, Central Valley Project Water Association, Pete Chadwick, Department of Fish and Game, Karl Halupka, U. S. National Marine Fisheries Service, Jim Starr, Department of Fish and Game, and Jim White, Department of Fish and Game.

METHODS

We developed a matrix for each CALFED scenario. All matrices consist of rows for each parameter expected to affect salmon survival in the Delta, and columns for each month and the sum of all months (Appendix A, pages A15-A20). We assign an integer value to each matrix cell reflecting the relative magnitude of adverse or beneficial effects of each parameter on the population of juvenile chinook in the Delta in each month. We scored Existing Conditions first, and then sequentially No Action, Common Programs, and Alternatives 1, 2, and 3. We completed two analyses for Alternatives 1, 2, and 3; for the alternatives with no additional storage and for the alternative with the maximum amount of storage being considered by CALFED. Initially, under Existing Conditions, integer values ranged from -3 to +3, but for matrices that were scored subsequent to Existing Conditions, values ranged outside -3 to +3 to maintain a consistent assessment of magnitude of effect relative to Existing Conditions.

The primary goal of scoring the Existing Conditions matrix is to obtain a set of consensus values that accurately describe present conditions. These values subsequently serve as a baseline for comparison with other scenarios. We assign Existing Conditions values that we consider reasonable in relation to limiting factors, without making any attempt to relate values to some specific set of historical conditions. We do not attempt to define "recovery," "restoration," or any other potential CALFED goals.

We consider both the magnitude of effect of each parameter and the proportion of the population present in the Delta in determining the value for each cell in the matrix. For example, a parameter causing a small change on a large proportion of the population could have the same population effect as a parameter causing a large change on a small proportion of the population, and thus could receive the same value.

We used best professional judgement to determine the degree to which each parameter affects salmon survival. We considered empirical relationships between parameters and survival, when relationships were available. Our evaluations were based on qualitative assessments of the degree to which water operations, water management facilities, and biological factors affect chinook salmon in the Delta.

For the Sacramento system, we consider each of the four races of chinook and their occurrence in the Delta as fry, smolts and yearlings. We integrate effects over all life stages of all races, including returning adults immigrating through the Delta, to determine values for each matrix cell.

To clarify and summarize the results in the matrix analysis, we created composite parameters (Tables 2 and 3; Appendix A, pages A15-A20). One composite parameter is Entrainment Losses. It is an estimate of losses occurring immediately in the vicinity of export diversions, either at the SWP and CVP south Delta diversions or at a new Hood facility. The overall estimate of Entrainment Losses is based primarily on the Percent Exposed parameter. If the sum of the other three entrainment related parameters (Screen efficiency/Predation, Trucking/ Handling and Clifton Court Forebay Loss) exceeds 3, we adjust the Percent Exposed parameter by -1 to reflect increase severity of Entrainment Losses.

Another composite parameter is Interior-Delta Survival. It is the survival of juvenile salmon diverted from the mainstem Sacramento River into the Mokelumne and San Joaquin portions of the Delta, and juvenile salmon emigrating through the San Joaquin portions of the Delta, exclusive of Entrainment Losses. Interior-Delta Survival is the sum of Flow Distribution, Delta Cross Channel, Predation, Temperature, and Salinity. Flow Distribution is based on flows in Old and Middle Rivers and San Joaquin River downstream of the Mokelumne River in the DSMII operation studies. Old and Middle Rivers connect the lower San Joaquin River to the south Delta export facilities.

We make separate estimates for the five component parameters under Interior-Delta Survival to reflect some knowledge of the independent effects of individual parameters, but are more certain of the overall estimate of Interior-Delta Survival than the values of the individual parameters. Our increased certainty is based on extensive smolt release and recapture experiments using hatchery smolts. Paired experiments result in an estimate of differential survival of smolts released simultaneously in the mainstem Sacramento River and in the Interior Delta, and subsequently recaptured downstream of the Delta. We recognize the survival of hatchery smolts probably does not reflect the survival of wild smolts precisely. Although the experiments were not designed to identify the sources of decreased survival, we assumed the sources to be the five parameters under Interior-Delta Survival. The results of the paired experiments were that survival of smolts diverted into the interior Delta was one third or less of the survival of smolts remaining in the mainstem Sacramento River (Table 1). The small proportion of chinook salvaged at the CVP and SWP south Delta exports indicates most of the decrease in survival is due to Interior-Delta Survival rather than Entrainment Losses.

Among the component parameters under Interior-Delta Survival, a majority of the subcommittee considers the Flow Distribution parameter to be a surrogate for effects associated with flow and olfactory cues, which are believed to be related to survival indirectly through mechanisms such as influencing the duration of emigration. Members of the committee all agree that the Flow Distribution effects are greatest near the south Delta export facilities when pumping rates are greatest. There is not consensus as to how widespread the effects are, and in particular whether they extend to the San Joaquin River in the central Delta where tidal flows far exceed net freshwater flows. Also, a minority of the subcommittee recommended it would be more appropriate to distribute some of the magnitude of effects represented in the Flow Distribution parameter among the other component parameters, such as, predation, temperature and salinity.

We based our evaluations on a single operation study for each scenario. The specific CALFED operation studies used for each scenario are: Existing Conditions - 558, No Action - 516, Alternative 1 without storage - 518, Alternative 1 with storage - 609, Alternative 2 without storage - 528, Alternative 2 with storage - 532a, Alternative 3 without storage - 595, and Alternative 3 with storage - 567. Flow changes associated with the Common Programs were evaluated by comparing flows below Hood and at Rio Vista in study 518 to flows in studies 516 and 518, and from tables in Appendix E of the 19 May 1998, draft modeling studies. The operation studies consist of flows at selected locations in the Delta, computed on a monthly timestep, then averaged over all years from 1922 to 1994, dry and critical years, and other subsets. We recognized the pitfalls associated with using average values, but we did not have time to explore fully, or to consider scoring, the full range of annual variability.

One of the parameters included in the matrices is Toxics. Acute and chronic toxic effects have been identified in the Delta, but results of standard toxicity bioassays have not been related directly to salmon in ways that the subcommittee felt competent to judge. Such effects would be expected to change due to the CALFED Water Quality Program, but that program is not yet described with sufficient specificity to judge how it might affect salmon. Water quality differences may also occur among alternatives due to differences in dilution in different areas of the Delta, or due to changes in the toxic constituents delivered to the Delta associated with changes in proportional flow from the Sacramento and San Joaquin rivers. The subcommittee did not feel competent to offer judgements on any of these aspects of toxicity.

In the matrices, the sum of all months is the overall annual effect of each parameter. Upon examining annual estimates for some parameters, or groups of parameters, in the Sacramento matrices, the subcommittee concluded that some parameters were not weighted properly in relation to other parameters. In such cases, the subcommittee divided or multiplied the annual estimate by a constant to provide the proper relationship among parameters or groups of parameters. Only the annual estimates were weighted in that fashion, so the reader needs to use caution in reaching conclusions based on comparing monthly values. For the San Joaquin system, weighting among parameters was incorporated directly as cells were assigned monthly values.

Two weighting factors were applied to the results of Sacramento River evaluations. When we compared the annual estimates for Entrainment Losses (-20) to the annual estimate for Interior-Delta Survival (-30), we concluded that this reflects an over weighting of Entrainment Losses (Table 2). Dividing Entrainment Losses by 4 brought them roughly into balance with empirical evidence on the relative effects on survival of these two parameters. Entrainment Losses in all Sacramento matrices were weighted in this fashion.

We identified another weighting disparity between relative magnitudes of Interior-Delta Survival and Flow below Hood in the Sacramento River. We concluded that Flow Below Hood should be multiplied by 2 to make the annual estimates for that parameter similar in range to the annual estimates for Interior-Delta Survival. Our justification for weighting survival in the Sacramento River and in the interior Delta nearly the same is that about four times as many salmon remain in the Sacramento River with the Delta Cross Channel gates closed as are diverted into the Delta, but the survival rate of juvenile salmon diverted into the interior Delta is reduced to one third or less of the rate for smolts that remain in the Sacramento River (Table 1).

RESULTS

Chinook Salmon From The Sacramento System

Existing Conditions

In summary, we determined that Existing Conditions have negative impacts primarily due to decreased Interior-Delta Survival and Entrainment Losses, both being substantial in all months except July and August.

No Action

We concluded that the only substantial difference in comparison to Existing Conditions was due to increases in exports of about 10% annually. The result of increased exports were shown as small increases in Entrainment Losses in January and February and small decreases in Interior-Delta Survival in December and January (Table 2).

Common Programs

The Common Programs that we judged would have some effect on survival of Sacramento salmon were the flow augmentations, wetland and riparian restoration (which translated into decreased predation, more extensive shallow water habitat, and enhanced food supply in the analysis), and agricultural diversion screening components of the Ecosystem Restoration Program (Table 2). We believe the effect of a flow augmentation of about 5% in March and May would be marginal in the Delta in relation to the other parameters' effects, therefore we increased the value of Flow Below Hood only during May in the matrix.

The relative effects of wetland and riparian restoration programs were difficult to judge. Where these habitats are available, they are used by juvenile salmon as rearing habitat, and provide both terrestrial and aquatic foods for both rearing and emigrating juvenile salmon. These habitats also would be likely to increase the abundance of predators, but most biologists agree that some net benefits would occur for salmon. We are not aware of experimental evidence that estimates the magnitude of such benefits. In the Ecosystem Restoration Program, CALFED proposes moderate increases in existing habitat in the Delta. It is not clear, however, how restored habitat will be distributed. Benefits would likely be greater than those we estimated if the habitat were concentrated in migration corridors for salmon. We concluded that restored habitat would provide modest rearing benefits, primarily from December through March, food supply benefits from December through May, and reduced in-Delta predation from March through May.

We estimated that screens on Delta agricultural diversions would reduce existing impacts in April, May, and June.

Alternative 1

We concluded that the primary changes in relation to Existing Conditions, beyond those attributable to the Common Programs, would be small decreases in Entrainment Losses (Table 2). The new fish screens at the intake to Clifton Court Forebay for both the CVP and SWP would improve screen efficiencies and eliminate predation losses now occurring in Clifton Court Forebay. Under Alternative 1 with storage, this improvement would be offset, to some degree, by exposure of a greater number of salmon to the screens from December through March, and decreased Interior-Delta Survival from October through March, due to increased exports.

Alternative 2

Several substantial changes would occur under Alternative 2 (Table 2). First, Entrainment Losses would increase. This would result from the combination of exposure to a new diversion at Hood and continued exposure to diversions in the south Delta. The fraction exposed to a diversion at Hood would be substantially greater than the fraction exposed now to the diversions in the south delta. The fraction exposed in the south Delta would not change much, as a result of a fairly complicated set of interactions. A larger fraction of the salmon would be diverted into the interior Delta, due to the lower flows below Hood intake increasing both the density of salmon in the Sacramento River and the proportion of flow diverted through

Georgiana Slough into the interior Delta. The increase would be more or less offset by more favorable flows in the interior Delta causing a smaller fraction of the salmon to go to the south Delta diversion and a larger fraction to migrate west towards the ocean.

A second adverse effect would be the Flow below Hood in the Sacramento River. The subcommittee expects this would decrease survival from September through June, with the greatest reductions occurring when the greatest fraction of flow is being diverted at Hood and when the flows are the lowest.

A third adverse effect would be the need to pass adult salmon migrating upstream through the San Joaquin-Mokelumne route to the Sacramento River. These fish would have to pass the Hood fish screen and pumping plant. While a bypass facility would be built, we determined it would probably impose new impacts on the adult population.

A beneficial effect under Alternative 2 would be improved Interior-Delta Survival for salmon smolts diverted through Georgiana Slough, due to more favorable flow distribution in the San Joaquin River and the avoidance of any need to open the Delta Cross Channel gates.

Alternative 3

This Alternative would not have the adult salmon passage problems at the Hood fish screens and pumping plant as would occur with Alternative 2. Otherwise the changes would parallel those for Alternative 2.

Entrainment Losses would increase (Table 2) for the same reasons described for Alternative 2, but the increases would be less than in Alternative 2, because exports from the south Delta would be reduced by about 80% and water diverted into Georgiana Slough would be distributed more favorably.

Survival in the Sacramento River below Hood would be reduced by essentially the same amount as for Alternative 2.

Interior-Delta survival would be even better than for Alternative 2, due to better flow distribution in the San Joaquin River.

Chinook Salmon from the San Joaquin System

Existing Conditions

Salmon from the San Joaquin system use the Delta over a smaller portion of the year than salmon from the Sacramento system (Appendix 2). Adults migrate upstream in the fall, some fry move downstream in January and February to rear in the Delta, and most of the juveniles emigrate downstream as smolts from March through June.

Entrainment Losses in the south Delta are controlled by the same parameters as those that control Entrainment Losses for salmon from the Sacramento, but the proportion of the population exposed to the screens is much greater because the screens are directly on their migratory pathway.

Interior-Delta Survival is also controlled by similar parameters, except that opening the Delta Cross Channel gates does not have a direct impact, but a barrier at the head of Old River reduces impacts.

Flows at Vernalis replace flows below Hood as a parameter. Flows at Vernalis have been shown to be correlated to escapement two and a half years later (Kjelson, Brandes, 1989). In addition, the survival of CWT smolts released in the south Delta is positively correlated to flow at Stockton and Vernalis (IEP Newsletter, Winter 1998).

Flows during the fall are inadequate for adult attraction and upstream passage. Entrainment Losses, Flows at Vernalis and Interior-Delta Survival are all of concern from January through June. Measures prescribed in the VAMP agreement and the head of Old River barrier partially mitigate adverse conditions in April and May.

No Action

Conditions are similar to Existing Conditions, except for slightly greater Entrainment Losses and poorer Flow Distribution in January and February (Table 3).

Common Programs

As for the Sacramento system, screening Agricultural Diversions and creating wetland and riparian habitat as part of the Ecosystem Restoration Program provide benefits of the same magnitude, and subject to the same caveats as those described for the Sacramento system (Table 3). In addition, flow augmentation provided as part of the Ecosystem Restoration Program are expected to improve conditions in May.

Alternative 1

New screens at the intake to Clifton Court Forebay would substantially reduce Entrainment Losses particularly for Alternative 1 without storage (Table 3). For this alternative with storage, Flow Distribution would become somewhat worse in January through March.

Alternative 2

In comparison to Alternative 1, Interior-Delta Survival would improve due to improved Flow Distribution downstream from the mouth of the Mokelumne River (Table 3). Otherwise conditions would be similar to those for Alternative 1.

Alternative 3

Reductions in diversions from the south Delta by about 80% would substantially reduce Entrainment Losses and improve Interior-Delta Survival due to Flow Distribution throughout the San Joaquin Delta being even more favorable than in Alternative 2 (Table 3). These changes would improve conditions both for adults migrating downstream and for young rearing in the Delta and migrating downstream.

QUESTIONS

1. Which population or life stages are most sensitive to diversion effects under no action and Alternatives 1, 2, and 3? When and where are they most affected?

Under the No Action Alternative, the San Joaquin basin chinook would be more vulnerable to effects of diversions from the south Delta than Sacramento chinook. All San Joaquin chinook migrate through the south Delta, where they are highly susceptible to direct entrainment, predation in Clifton Court Forebay, and reduced survival associated with unfavorable flow distribution in the southern and a much smaller proportion of the population of Sacramento chinook are affected by diversions from the south Delta.

Under Alternative 1, San Joaquin and Sacramento chinook Entrainment Losses would be reduced by elimination of Clifton Court Forebay predation, although the altered flow distribution still would affect San Joaquin and Sacramento chinook through prolonged exposure to a variety of mortality sources in the Delta.

Under Alternative 2, the entire population of Sacramento chinook would emigrate past Hood and thus would be exposed to a screened diversion at Hood and to reductions in flow in the Sacramento River downstream from Hood. The San Joaquin and Sacramento chinook that would emigrate through the interior Delta would still be affected by changes in interior-Delta hydrodynamics, although to a lesser degree than in Alternative 1, because of the increased frequency of net downstream flows below the mouth of the Mokelumne River. An effect unique to Alternative 2 would be that adult salmon returning to the Sacramento basin that have been attracted to the Mokelumne River portion of the Delta would be affected adversely due to delays in migration and other impacts at whatever fish passage facility would be constructed at Hood to return these salmon to the Sacramento River.

Under Alternative 3, San Joaquin chinook would benefit from restored flow distribution patterns in the south and central Delta, reduced pumping, and improved screens in the south Delta. Sacramento chinook would still be adversely affected by reduced flows in the Sacramento River. The effect of altered flow distribution on the survival of salmon that enter the interior Delta would be better than for Alternatives 1 or 2.

Juvenile chinook are considered to be at greatest risk to diversion effects due to their need to find their way through the Delta to the ocean. Yearlings and smolts are considered more subject to diversion effects than rearing fry, because they are actively migrating. Fry rearing in the Delta are important to salmon production, especially in wet years, and their survival depends on conditions over a several month period prior to their migrating to the ocean as smolts. During their emigration, they are presumably just as subject to diversion effects as smolts entering the Delta after rearing in upstream areas.

2. Can diversion effects in the South Delta be offset by habitat improvements and other common program actions?

Modest benefits for juvenile chinook were estimated due to enhanced food supply and physiological condition, reduced toxicity, reduced entrainment in small diversions, and more extensive rearing and escape habitat associated with the ERP element of the Common Programs.

Considerable uncertainty surrounds how the ERP will be implemented and thus the magnitude of associated benefits. The presumed benefit for salmon from improvement or type conversion of existing habitat is proportionally modest. If the ERP emphasized improving habitat along migration corridors for salmon, benefits would be greater than estimated in this analysis. Increased flows in March and May in the Sacramento River and in May in the San Joaquin River provided by the ERP would provide a minor improvement in chinook survival in the Delta, in addition to the benefits that would be expected upstream of the Delta. Overall, we concluded that the common programs would not provide enough benefits in the Delta to offset fully diversion effects.

The subcommittee did not attempt to estimate benefits to salmon from the Water Quality Program.

3. To what extent can Alternatives 1, 2 and 3 offset diversion effects as presently configured?

Our answer to question 1 answers this question as well.

4. To what extent can diversion effects be offset by modifications to the Alternatives or by operational changes?

The subcommittee has not addressed this question.

5. What is the risk and chances of success of species recovery for each alternative?

The probability for recovery depends on conditions throughout the life history of salmon. Because the subcommittee considered only needs of young and adults in the Delta, the following answers only partially address the question of recovery.

No Action- The No Action scenario continues to rely on closure of the Delta Cross Channel gates from November through June to improve the survival of salmon migrating down the Sacramento River. This has a high risk of conflict with water supply operations during low flow periods.

The ongoing efforts of the Ops Group to improve salmon survival under Existing Conditions in the face of limited operational flexibility indicates that very little "recovery" potential would exist under the No Action scenario.

Common Programs- See the answer to Question 2.

Alternative 1- As with the No Action scenario, reliance on closure of the Delta Cross Channel gates would continue.

Experience with fish screen operations in the south Delta indicate a high probability that the benefits expected from improved fish screens would be achieved. Such benefits are limited by the need for continued handling and trucking, but experimental evidence indicates this is less of a risk for salmon than for many other species.

Alternative 1 includes measures such as the Water Use Efficiency and Water Transfer programs, which would somewhat increase flexibility in water supply operations. Thus Alternative 1 offers some potential for shifting diversions to times less detrimental to salmon, but such shifts would be likely to increase impacts on other species, would sometimes interfere with water supply benefits, and probably would not be sufficient to cause major improvements in salmon production.

Overall, Alternative 1 is not likely to result in significant increases in survival for salmon from the Sacramento system.

For the San Joaquin, Alternative 1 would increase salmon survival somewhat, due to the improved structure and location of the fish screens.

Alternative 2- Risks for new screens in the south Delta are the same as described for Alternative 1. Several new risks for salmon from the Sacramento system are inherent in Alternative 2 associated with the diversion at Hood. One is the fish screens themselves. Advances in fish screen design provide good evidence that a successful screen can be built, but all large fish screens have inherent risks. Even the best screen would increase the risk for salmon from the Sacramento system, due to the greater exposure of the population to the screen. Also, the screen and the pumping plant that would accompany it would pose a new risk for adults migrating upstream. Finally, the diversion would reduce flows in the Sacramento River below Hood. The subcommittee recognized considerable uncertainty in the consequences of that reduction, based both on questions about evidence of the effects on survival and about the magnitude of flow reductions that would occur over the range of operating conditions. The subcommittee, however, believes that Alternative 2 would pose risks for salmon from the Sacramento system greater than any other alternative. For salmon from the San Joaquin, Alternative 2 would be intermediate between Alternatives 1 and 3.

Alternative 3- San Joaquin basin chinook have the greatest potential to benefit from Alternative 3, but the improvement may not ensure "recovery". Flows at Vernalis are strongly correlated to population levels of San Joaquin salmon, and although the Alternatives would improve San Joaquin flows as a result of ERP flows and VAMP, the improvements in survival are expected to be small.

The benefits that are most certain are the reduction in entrainment losses associated with the large reduction in diversions from the south Delta. Those benefits would be greatest for San Joaquin stocks and for those smolts diverted into the central Delta from the Sacramento River via Georgiana Slough.

Alternative 3 would not have the risk for upstream migrants that Alternative 2 would have because there are no attraction flows for adults in the central Delta. Other risks of the Hood diversion would be essentially the same as those described for Alternative 2.

6. What increment of protection or improvement for fish species will be provided by other programs such as the CVPIA, biological opinions?

The increment of improvement for the various programs is difficult to quantify, but if most of the actions contained within the Anadromous Fish Restoration Plan are implemented, substantial improvement should be achieved. The CALFED program, as it is proposed, would include restoration elements not included in CVPIA and the Winter Run and Delta Smelt Biological Opinions.

7. What degree of benefit and impact will the common programs provide?

We estimated that improvement would occur with the common programs. Much of the benefit predicted is due to the creation of additional shallow water habitat of several different types. The effect on salmon is uncertain, largely due to the scarcity of evidence regarding the ecological tradeoffs associated with increasing restored habitat area in an aquatic ecosystem dominated by introduced species. Salmon, particularly presmolts, are likely to use restored habitat. Although the habitat will also be favorable for predators, the increased cover and food supply will increase salmon survival in the opinion of most salmon biologists. Screening Delta diversions and improved Delta water quality are also expected to be beneficial.

8. What are the direct and indirect effects on chinook populations resulting from each Alternative and what is the expected response of the populations to these effects?

The Results section and summary tables included in this report address this question. However, the subcommittee is concerned that some readers may focus on the summarized information without appreciating the imprecision and uncertainties involved. The numbers in the summary tables should be interpreted carefully and are most appropriately used to support broad generalizations such as those offered after the summaries. Imprecision and uncertainty are involved throughout, and the subcommittee is particularly concerned with Flow Below Hood and Interior-Delta Survival. We did not have adequate time to explore and cite the available evidence to the degree that we would have liked, and even if we had, considerable uncertainty would remain as to both the magnitude of effects and the controlling mechanisms.

The annual sums are useful for gross comparisons among scenarios, but the monthly evaluations are essential for more fully understanding the scenarios and formulating alternative operations.

A summary for the Sacramento system (Table 1) is that compared to Existing Conditions the Common Programs would provide a substantial benefit, but some negative consequences would persist. With Alternatives 1 and 3, approximately the same net magnitude of consequences would persist as with the Common Programs, but for quite different reasons. For Alternative 1 there would be little change from the Common Programs for any category of parameters, and for Alternative 3, our estimate of improvements in Interior-Delta Survival would be offset by detriments from flow reductions below Hood. For both Alternatives 2 and 3, the consequences of flow reductions below Hood would vary considerably depending on the magnitude of flow. In high flow periods, effects might be inconsequential, but in low flow periods, survival would probably be less than the approximation of the overall average included in the summary.

A summary for the San Joaquin system (Table 2) is that compared to Existing Conditions the Common Programs would provide benefits similar to those provided for the Sacramento system. As in the Sacramento system, Alternative 1 would provide little change from the Common Programs. For Alternatives 2 and 3 the consequences would be quite different than for the Sacramento system. Alternative 3 would clearly be superior, and Alternative 2 would provide intermediate benefits.

Table 1
Survival indices to Chipps Island for coded wire tagged fall run smolts and late-fall run yearlings released at Ryde and in Georgiana Slough between 1992 and 1996.

Fall run

Date	Ryde	Georgiana Slough	Ratio (GS/R)
4/6/92	1.36	0.42	0.30
4/14/92	2.14	0.73	0.34
4/27/92	1.67	0.20	0.12
4/14/93	0.41	0.13	0.31
5/10/93	0.86	0.29	0.33
4/12/94	0.20	0.06	0.30
4/25/94	0.18	0.11	0.61
		Mean	= 0.33

Late fall

Date	Ryde	Georgiana Slough	Ratio (GS/R)
12/2/93	1.91	0.28	0.14
12/5/94	0.57	0.16	0.28
1/4/95	0.33	0.12	0.36
1/10/96	0.66	0.17	0.25
1/13/98*	0.90	0.24	0.27
12/4/97*	0.70	0.03	0.04
		Mean =	0.22

* Preliminary data

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Table 2
Summary of matrices evaluating the effects in the Delta on chinook salmon from the Sacramento River basin. Alternatives 1, 2, and 3 were evaluated without any new storage and with maximum new storage contemplated by CALFED (results are presented: without/with).

Effects	Existing	No Action	Common	Alt. 1	Alt. 2	Alt. 3
Entrainment Losses	-5	-6	-6	-4 / -5	-7 / -8	-6 / -7
Flow below Hood	-6	-6	-4	-4	-28	-28
Interior-Delta Survival	-30	-32	-25	-25 / -31	-7 / -12	0
Shallow water habitat, food supply & ag diversion screens	-3	-3	+10	+10	+10	+10
Upstream migration of adult salmon	0	0	0	0	-19	0
Total	-44	-47	-25	-23 / -30	-51 / -57	-24 / -25
Change from existing conditions		-3	+19	+21 /+14	-7 / -13	+20 /+19
Change from Common Programs				+2 / -5	-26 / -32	+1 / 0

Table 3
Summary of matrices evaluating the effects in the Delta on chinook salmon from the San Joaquin River basin. Alternatives 1, 2, and 3 were evaluated without any new storage and with maximum new storage contemplated by CALFED (results are presented: without/with).

Effects	Existing	No Action	Common	Alt. 1	Alt. 2	Alt. 3
Entrainment Losses	-12	-13	-13	-7 / -10	-7 / -10	-2 / -2
Vernalis flow	-18	-18	-17	-17	-17	-17
Interior-Delta Survival	-23	-25	-19	-19 / -22	-2 / -5	+14 /+14
Shallow water habitat, food supply & ag diversion screens	-3	-3	+8	+8	+8	+8
Total	-56	-59	-41	-35 / -41	-18 / -24	+3 / +3
Change from existing conditions		-3	+15	+21 /+15	+38 /+32	+59 /+59
Change from Common Programs				+6 / 0	+23 /+17	+44 /+44

EXISTING CONDITIONS (Baseline)

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep		SUM	Mod	MOD SUM
Entrainment	-1	-2	-2	-1	-1	-3	-3	-3	-2	0	0	-2		-20	/4	-5
													sum			
% Population Exposed	-1	-2	-2	-1	-1	-2	-2	-2	-1	0	0	-1	-15			
Screen Efficiency/Predati	0	0	-1	-1	-1	-1	-1	-1	-1	-1	-1	0	-9			
Handling/Trucking Losse	0	0	0	0	0	0	0	-1	-1	-1	-1	-1	-5			
CCFB Predation Losses	-2	-1	-1	-1	-1	-2	-3	-3	-3	-3	-3	-3	-26			
Interior Delta Survival	-2	-3	-5	-3	-2	-3	-2	-4	-5	0	0	-1		-30	na	-30
													sum			
Flow Distribution	-1	-2	-3	-2	-1	-1	0	0	-1	0	0	-1	-12			
Cross Channel Operation	-1	-1	-1	0	0	0	0	0	-1	0	0	0	-4			
Predation in the Delta	0	0	-1	-1	-1	-2	-2	-2	-1	0	0	0	-10			
Temperature	0	0	0	0	0	0	0	-2	-2	0	0	0	-4			
Salinity	0	0	0	0	0	0	0	0	0	0	0	0	0			
Flow below Hood	0	0	0	0	0	0	-1	-1	-1	0	0	0		-3	x2	-6
Shallow Water Habitat	0	0	0	0	0	0	0	0	0	0	0	0		0		0
Food Supply	0	0	0	0	0	0	0	0	0	0	0	0		0		0
Ag Diversions	0	0	0	0	0	0	-1	-1	-1	0	0	0		-3		-3
Adult migration	0	0	0	0	0	0	0	0	0	0	0	0		0		0
Toxics (dilution/inputs)	*	*	*	*	*	*	*	*	*	*	*	*		0		0
													TOTAL	-56		-44

NO ACTION ALTERNATIVE

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep		SUM	Mod	MOD SUM
Entrainment	-1	-2	-2	-2	-2	-3	-3	-3	-2	0	0	-2		-22	/4	-6
													sum			
% Population Exposed	-1	-2	-2	-2	-2	-2	-2	-2	-1	0	0	-1	-17			
Screen Efficiency/Predati	0	0	-1	-1	-1	-1	-1	-1	-1	-1	-1	0	-9			
Handling/Trucking Losse	0	0	0	0	0	0	0	-1	-1	-1	-1	-1	-5			
CCFB Predation Losses	-2	-1	-1	-1	-1	-2	-3	-3	-3	-3	-3	-3	-26			
Interior Delta Survival	-2	-3	-6	-4	-2	-3	-2	-4	-5	0	0	-1		-32	na	-32
													sum			
Flow Distribution	-1	-2	-4	-3	-1	-1	0	0	-1	0	0	-1	-14			
Cross Channel Operation	-1	-1	-1	0	0	0	0	0	-1	0	0	0	-4			
Predation in the Delta	0	0	-1	-1	-1	-2	-2	-2	-1	0	0	0	-10			
Temperature	0	0	0	0	0	0	0	-2	-2	0	0	0	-4			
Salinity	0	0	0	0	0	0	0	0	0	0	0	0	0			
Flow below Hood	0	0	0	0	0	0	-1	-1	-1	0	0	0		-3	x2	-6
Shallow Water Habitat	0	0	0	0	0	0	0	0	0	0	0	0		0		0
Food Supply	0	0	0	0	0	0	0	0	0	0	0	0		0		0
Ag Diversions	0	0	0	0	0	0	-1	-1	-1	0	0	0		-3		-3
Adult migration	0	0	0	0	0	0	0	0	0	0	0	0		0		0
Toxics (dilution/inputs)	*	*	*	*	*	*	*	*	*	*	*	*		0		0
													TOTAL	-60		-47

COMMON PROGRAMS

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep		SUM	Mod	MOD SUM
Entrainment	-1	-2	-2	-2	-2	-3	-3	-3	-2	0	0	-2		-22	/4	-6
													sum			
% Population Exposed	-1	-2	-2	-2	-2	-2	-2	-2	-1	0	0	-1	-17			
Screen Efficiency/Predati	0	0	-1	-1	-1	-1	-1	-1	-1	-1	-1	0	-9			
Handling/Trucking Losse	0	0	0	0	0	0	0	-1	-1	-1	-1	-1	-5			
CCFB Predation Losses	-2	-1	-1	-1	-1	-2	-3	-3	-3	-3	-3	-3	-26			
Interior Delta Survival	-2	-3	-5	-3	-1	-2	-1	-3	-4	0	0	-1		-25	na	-25
													sum			
Flow Distribution	-1	-2	-4	-3	-1	-1	0	0	-1	0	0	-1	-14			
Cross Channel Operation	-1	-1	-1	0	0	0	0	0	-1	0	0	0	-4			
Predation in the Delta	0	0	0	0	0	-1	-1	-1	0	0	0	0	-3			
Temperature	0	0	0	0	0	0	0	-2	-2	0	0	0	-4			
Salinity	0	0	0	0	0	0	0	0	0	0	0	0	0			
Flows below Hood	0	0	0	0	0	0	-1	0	-1	0	0	0		-2	x2	-4
Shallow Water Habitat	0	0	1	1	1	1	0	0	0	0	0	0		4		4
Food Supply	0	0	1	1	1	1	1	1	0	0	0	0		6		6
Ag Diversions exposure)	0	0	0	0	0	0	0	0	0	0	0	0		0		0
Adult migration	0	0	0	0	0	0	0	0	0	0	0	0		0		0
Toxics (dilution/inputs)	*	*	*	*	*	*	*	*	*	*	*	*		0		0
													TOTAL	-39		-25

ALTERNATIVE 1 (without storage)

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep		SUM	Mod	MOD SUM
Entrainment	-1	-2	-2	-2	-2	-2	-2	-2	-1	0	0	-1		-17	/4	-4
													sum			
% Population Exposed	-1	-2	-2	-2	-2	-2	-2	-2	-1	0	0	-1	-17			
Screen Efficiency/Predati	0	0	0	0	0	0	-1	-1	-1	-1	-1	0	-5			
Handling/Trucking Losse	0	0	0	0	0	0	0	-1	-1	-1	-1	-1	-5			
CCFB Predation Losses	0	0	0	0	0	0	0	0	0	0	0	0	0			
Interior Delta Survival	-2	-3	-5	-3	-1	-2	-1	-3	-4	0	0	-1		-25	na	-25
													sum			
Flow Distribution	-1	-2	-4	-3	-1	-1	0	0	-1	0	0	-1	-14			
Cross Channel Operation	-1	-1	-1	0	0	0	0	0	-1	0	0	0	-4			
Predation in the Delta	0	0	0	0	0	-1	-1	-1	0	0	0	0	-3			
Temperature	0	0	0	0	0	0	0	-2	-2	0	0	0	-4			
Salinity	0	0	0	0	0	0	0	0	0	0	0	0	0			
Flows below Hood	0	0	0	0	0	0	-1	0	-1	0	0	0		-2	x2	-4
Shallow Water Habitat	0	0	1	1	1	1	0	0	0	0	0	0		4		4
Food Supply	0	0	1	1	1	1	1	1	0	0	0	0		6		6
Ag Diversions	0	0	0	0	0	0	0	0	0	0	0	0		0		0
Adult Migration	0	0	0	0	0	0	0	0	0	0	0	0		0		0
Toxics (dilution/inputs)	*	*	*	*	*	*	*	*	*	*	*	*		0		0
													TOTAL	-34		-23

ALTERNATIVE 2 (without storage)

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep		SUM	Mod	MOD SUM
Entrainment	-2	-4	-4	-3	-2	-2	-3	-3	-2	0	0	-2		-27	/4	-7
													sum			
% Population Exposed	*	*	*	*	*	*	*	*	*	*	*	*	0			
Screen Efficiency/Predati	*	*	*	*	*	*	*	*	*	*	*	*	0			
Handling/Trucking Losse	*	*	*	*	*	*	*	*	*	*	*	*	0			
CCFB Predation Losses	*	*	*	*	*	*	*	*	*	*	*	*	0			
Interior Delta Survival	0	0	-1	-1	1	-1	0	-2	-3	0	0	0		-7	na	-7
													sum			
Flow Distribution	0	0	-1	-1	1	0	1	1	0	0	0	0	1			
Cross Channel Operation	0	0	0	0	0	0	0	0	0	0	0	0	0			
Predation in the Delta	0	0	0	0	0	-1	-1	-1	-1	0	0	0	-4			
Temperature	0	0	0	0	0	0	0	-2	-2	0	0	0	-4			
Salinity	0	0	0	0	0	0	0	0	0	0	0	0	0			
Flows below Hood	-1	-1	-1	-1	-2	-2	-2	-1	-2	0	0	-1		-14	x2	-28
Shallow Water Habitat	0	0	1	1	1	1	0	0	0	0	0	0		4		4
Food Supply	0	0	1	1	1	1	1	1	0	0	0	0		6		6
Ag Diversions	0	0	0	0	0	0	0	0	0	0	0	0		0		0
Adult migration	-2	-2	-1	-1	-2	-2	-1	-2	-2	-1	-1	-2		-19		-19
Toxics (dilution/inputs)	*	*	*	*	*	*	*	*	*	*	*	*		0		0
														-57		-51

ALTERNATIVE 3 (without storage)

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep		SUM	Mod	MOD SUM
Entrainment	-2	-3	-3	-2	-2	-2	-3	-3	-2	0	0	-2		-24	/4	-6
													sum			
% Population Exposed	*	*	*	*	*	*	*	*	*	*	*	*	0			
Screen Efficiency/Predati	*	*	*	*	*	*	*	*	*	*	*	*	0			
Handling/Trucking Losse	*	*	*	*	*	*	*	*	*	*	*	*	0			
CCFB Predation Losses	*	*	*	*	*	*	*	*	*	*	*	*	0			
Interior Delta Survival	0	1	1	1	2	0	0	-2	-3	0	0	0		0	na	0
													sum			
Flow Distribution	0	1	1	1	2	1	1	1	0	0	0	0	8			
Cross Channel Operation	0	0	0	0	0	0	0	0	0	0	0	0	0			
Predation in the Delta	0	0	0	0	0	-1	-1	-1	-1	0	0	0	-4			
Temperature	0	0	0	0	0	0	0	-2	-2	0	0	0	-4			
Salinity	0	0	0	0	0	0	0	0	0	0	0	0	0			
Flows below Hood	-1	-1	-1	-1	-2	-2	-2	-1	-2	0	0	-1		-14	x2	-28
Shallow Water Habitat	0	0	1	1	1	1	0	0	0	0	0	0		4		4
Food Supply	0	0	1	1	1	1	1	1	0	0	0	0		6		6
Ag Diversions	0	0	0	0	0	0	0	0	0	0	0	0		0		0
Adult migration	0	0	0	0	0	0	0	0	0	0	0	0		0		0
Toxics	*	*	*	*	*	*	*	*	*	*	*	*		0		0
														-28		-24

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ALTERNATIVE 1 (with storage)

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep		SUM	Mod	MOD SUM
Entrainment	-1	-2	-3	-3	-3	-3	-2	-2	-1	0	0	-1		-21	/4	-5
													sum			
% Population Exposed	-1	-2	-3	-3	-3	-3	-2	-2	-1	0	0	-1	-21			
Screen Efficiency/Predati	0	0	0	0	0	0	-1	-1	-1	-1	-1	0	-5			
Handling/Trucking Losse	0	0	0	0	0	0	0	-1	-1	-1	-1	-1	-5			
CCFB Predation Losses	0	0	0	0	0	0	0	0	0	0	0	0	0			
Interior Delta Survival	-3	-4	-6	-4	-2	-3	-1	-3	-4	0	0	-1		-31	na	-31
													sum			
Flow Distribution	-2	-3	-5	-4	-2	-2	0	0	-1	0	0	-1	-20			
Cross Channel Operation	-1	-1	-1	0	0	0	0	0	-1	0	0	0	-4			
Predation in the Delta	0	0	0	0	0	-1	-1	-1	0	0	0	0	-3			
Temperature	0	0	0	0	0	0	0	-2	-2	0	0	0	-4			
Salinity	0	0	0	0	0	0	0	0	0	0	0	0	0			
Flows below Hood	0	0	0	0	0	0	-1	0	-1	0	0	0		-2	x2	-4
Shallow Water Habitat	0	0	1	1	1	1	0	0	0	0	0	0		4		4
Food Supply	0	0	1	1	1	1	1	1	0	0	0	0		6		6
Ag Diversions	0	0	0	0	0	0	0	0	0	0	0	0		0		0
Adult Migration	0	0	0	0	0	0	0	0	0	0	0	0		0		0
Toxics (dilution/inputs)	*	*	*	*	*	*	*	*	*	*	*	*		0		0
													TOTAL	-44		-30

ALTERNATIVE 2 (with storage)

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep		SUM	Mod	MOD SUM
Entrainment	-2	-4	-5	-4	-3	-3	-3	-3	-2	0	0	-2		-31	/4	-8
													sum			
% Population Exposed	*	*	*	*	*	*	*	*	*	*	*	*	0			
Screen Efficiency/Predati	*	*	*	*	*	*	*	*	*	*	*	*	0			
Handling/Trucking Losse	*	*	*	*	*	*	*	*	*	*	*	*	0			
CCFB Predation Losses	*	*	*	*	*	*	*	*	*	*	*	*	0			
Interior Delta Survival	-1	-1	-2	-2	0	-1	0	-2	-3	0	0	0		-12	na	-12
													sum			
Flow Distribution	-1	-1	-2	-2	0	0	1	1	0	0	0	0	-4			
Cross Channel Operation	0	0	0	0	0	0	0	0	0	0	0	0	0			
Predation in the Delta	0	0	0	0	0	-1	-1	-1	-1	0	0	0	-4			
Temperature	0	0	0	0	0	0	0	-2	-2	0	0	0	-4			
Salinity	0	0	0	0	0	0	0	0	0	0	0	0	0			
Flows below Hood	-1	-1	-1	-1	-2	-2	-2	-1	-2	0	0	-1		-14	x2	-28
Shallow Water Habitat	0	0	1	1	1	1	0	0	0	0	0	0		4		4
Food Supply	0	0	1	1	1	1	1	1	0	0	0	0		6		6
Ag Diversions	0	0	0	0	0	0	0	0	0	0	0	0		0		0
Adult migration	-2	-2	-1	-1	-2	-2	-1	-2	-2	-1	-1	-2		-19		-19
Toxics (dilution/inputs)	*	*	*	*	*	*	*	*	*	*	*	*		0		0
														-66		-57

ALTERNATIVE 3 (with storage)

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep		SUM	Mod	MOD SUM
Entrainment	-2	-3	-4	-3	-3	-3	-3	-3	-2	0	0	-2		-28	/4	-7
													sum			
% Population Exposed	*	*	*	*	*	*	*	*	*	*	*	*	0			
Screen Efficiency/Predati	*	*	*	*	*	*	*	*	*	*	*	*	0			
Handling/Trucking Losse	*	*	*	*	*	*	*	*	*	*	*	*	0			
CCFB Predation Losses	*	*	*	*	*	*	*	*	*	*	*	*	0			
Interior Delta Survival	0	1	1	1	2	0	0	-2	-3	0	0	0		0	na	0
													sum			
Flow Distribution	0	1	1	1	2	1	1	1	0	0	0	0	8			
Cross Channel Operation	0	0	0	0	0	0	0	0	0	0	0	0	0			
Predation in the Delta	0	0	0	0	0	-1	-1	-1	-1	0	0	0	-4			
Temperature	0	0	0	0	0	0	0	-2	-2	0	0	0	-4			
Salinity	0	0	0	0	0	0	0	0	0	0	0	0	0			
Flows below Hood	-1	-1	-1	-1	-2	-2	-2	-1	-2	0	0	-1		-14	x2	-28
Shallow Water Habitat	0	0	1	1	1	1	0	0	0	0	0	0		4		4
Food Supply	0	0	1	1	1	1	1	1	0	0	0	0		6		6
Ag Diversions	0	0	0	0	0	0	0	0	0	0	0	0		0		0
Adult migration	0	0	0	0	0	0	0	0	0	0	0	0		0		0
Toxics	*	*	*	*	*	*	*	*	*	*	*	*		0		0
														-32		-25

EXISTING CONDITIONS (Baseline)

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep		SUM
Entrainment	0	0	0	-1	-1	-3	-2	-2	-3	0	0	0		-12
													sum	
% Population Exposed	0	0	0	-1	-1	-1	-1	-1	-1	0	0	0	-6	
Screen Efficiency/Predati	0	0	0	0	0	0	0	-1	-1	-1	-1	-1	-5	
Handling/Trucking Loss	0	0	0	0	0	0	0	-1	-1	-1	-1	-1	-5	
CCFB Loss	0	0	0	-1	-1	-2	-3	-3	-3	0	0	0	-13	
Interior Delta Survival	0	0	-1	-2	-2	-4	-3	-4	-6	0	0	-1		-23
													sum	
Flow Distribution	-1	-1	-1	-1	-1	-2	-1	-1	-2	0	0	-1	-12	
Upper Old River Barrier	1	1	0	0	0	0	1	1	0	0	0	0	4	
Predation in the Delta	0	0	0	-1	-1	-2	-2	-2	-1	0	0	0	-9	
Temperature	0	0	0	0	0	0	-1	-2	-3	0	0	0	-6	
Salinity	0	0	0	0	0	0	0	0	0	0	0	0	0	
Flow at Vernalis	-1	-1	-1	-1	-2	-2	-3	-3	-3	0	0	-1		-18
Shallow Water Habitat	0	0	0	0	0	0	0	0	0	0	0	0		0
Food Supply	0	0	0	0	0	0	0	0	0	0	0	0		0
Ag Diversions	0	0	0	0	0	0	-1	-1	-1	0	0	0		-3
Adult Migration	na	na	na	na	na	na	na	na	na	na	na	na		0
Toxics (dilution/inputs)	*	*	*	*	*	*	*	*	*	*	*	*		0
													TOTAL	-56

NO ACTION ALTERNATIVE

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep		SUM
Entrainment	0	0	0	-1	-2	-3	-2	-2	-3	0	0	0		-13
													sum	
% Population Exposed	*	*	*	*	*	*	*	*	*	*	*	*	0	
Screen Efficiency/Predati	*	*	*	*	*	*	*	*	*	*	*	*	0	
Handling/Trucking Losse	*	*	*	*	*	*	*	*	*	*	*	*	0	
CCFB Losses	*	*	*	*	*	*	*	*	*	*	*	*	0	
Interior Delta Survival	0	0	-1	-3	-3	-4	-3	-4	-6	0	0	-1		-25
													sum	
Flow Distribution	-1	-1	-1	-2	-2	-2	-1	-1	-2	0	0	-1	-14	
Upper Old River Barrier	1	1	0	0	0	0	1	1	0	0	0	0	4	
Predation in the Delta	0	0	0	-1	-1	-2	-2	-2	-1	0	0	0	-9	
Temperature	0	0	0	0	0	0	-1	-2	-3	0	0	0	-6	
Salinity	0	0	0	0	0	0	0	0	0	0	0	0	0	
Flow at Vernalis	-1	-1	-1	-1	-2	-2	-3	-3	-3	0	0	-1		-18
Shallow Water Habitat	0	0	0	0	0	0	0	0	0	0	0	0		0
Food Supply	0	0	0	0	0	0	0	0	0	0	0	0		0
Ag Diversions	0	0	0	0	0	0	-1	-1	-1	0	0	0		-3
Adult Migration	na	na	na	na	na	na	na	na	na	na	na	na		0
Toxics (dilution/inputs)	*	*	*	*	*	*	*	*	*	*	*	*		0
													TOTAL	-59

COMMON PROGRAMS

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep		SUM
Entrainment	0	0	0	-1	-2	-3	-2	-2	-3	0	0	0		-13
													sum	
% Population Exposed	*	*	*	*	*	*	*	*	*	*	*	*	0	
Screen Efficiency/Predati	*	*	*	*	*	*	*	*	*	*	*	*	0	
Handling/Trucking Losse	*	*	*	*	*	*	*	*	*	*	*	*	0	
CCFB Losses	*	*	*	*	*	*	*	*	*	*	*	*	0	
Interior Delta Survival	0	0	-1	-2	-2	-3	-2	-3	-5	0	0	-1		-19
													sum	
Flow Distribution	-1	-1	-1	-2	-2	-2	-1	-1	-2	0	0	-1	-14	
Upper Old River Barrier	1	1	0	0	0	0	1	1	0	0	0	0	4	
Predation in the Delta	0	0	0	0	0	-1	-1	-1	0	0	0	0	-3	
Temperature	0	0	0	0	0	0	-1	-2	-3	0	0	0	-6	
Salinity	0	0	0	0	0	0	0	0	0	0	0	0	0	
Flow at Vernalis	-1	-1	-1	-1	-2	-2	-3	-2	-3	0	0	-1		-17
Shallow Water Habitat	0	0	0	1	1	1	0	0	0	0	0	0		3
Food Supply	0	0	0	1	1	1	1	1	0	0	0	0		5
Ag Diversions	0	0	0	0	0	0	0	0	0	0	0	0		0
Adult Migration	na	na	na	na	na	na	na	na	na	na	na	na		0
Toxics (dilution/inputs)	*	*	*	*	*	*	*	*	*	*	*	*		0
													TOTAL	-41

ALTERNATIVE 1 (without storage)

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep		SUM
Entrainment	0	0	0	0	-1	-2	-1	-1	-2	0	0	0		-7
													sum	
% Population Exposed	*	*	*	*	*	*	*	*	*	*	*	*	0	
Screen Efficiency/Predati	*	*	*	*	*	*	*	*	*	*	*	*	0	
Handling/Trucking Losse	*	*	*	*	*	*	*	*	*	*	*	*	0	
CCFB Losses	*	*	*	*	*	*	*	*	*	*	*	*	0	
Interior Delta Survival	0	0	-1	-2	-2	-3	-2	-3	-5	0	0	-1		-19
Flow Distribution	-1	-1	-1	-2	-2	-2	-1	-1	-2	0	0	-1	-14	
Upper Old River Barrier	1	1	0	0	0	0	1	1	0	0	0	0	4	
Predation in the Delta	0	0	0	0	0	-1	-1	-1	0	0	0	0	-3	
Temperature	0	0	0	0	0	0	-1	-2	-3	0	0	0	-6	
Salinity	0	0	0	0	0	0	0	0	0	0	0	0	0	
Flow at Vernalis	-1	-1	-1	-1	-2	-2	-3	-2	-3	0	0	-1		-17
Shallow Water Habitat	0	0	0	1	1	1	0	0	0	0	0	0		3
Food Supply	0	0	0	1	1	1	1	1	0	0	0	0		5
Ag Diversions	0	0	0	0	0	0	0	0	0	0	0	0		0
Adult Migration	na	na	na	na	na	na	na	na	na	na	na	na		0
Toxics (dilution/inputs)	*	*	*	*	*	*	*	*	*	*	*	*		0
													TOTAL	-35

ATERNATIVE 2 (without storage)

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep		SUM
Entrainment	0	0	0	0	-1	-2	-1	-1	-2	0	0	0		-7
													sum	
% Population Exposed	*	*	*	*	*	*	*	*	*	*	*	*	0	
Screen Efficiency/Predati	*	*	*	*	*	*	*	*	*	*	*	*	0	
Trucking/Handling Losse	*	*	*	*	*	*	*	*	*	*	*	*	0	
CCFB Losses	*	*	*	*	*	*	*	*	*	*	*	*	0	
Interior Delta Survival	1	1	0	0	1	0	-1	-2	-2	0	0	0		-2
													sum	
Flow Distribution	0	0	0	0	1	1	0	0	1	0	0	0	3	
Upper Old River Barrier	1	1	0	0	0	0	1	1	0	0	0	0	4	
Predation in the Delta	0	0	0	0	0	-1	-1	-1	0	0	0	0	-3	
Temperature	0	0	0	0	0	0	-1	-2	-3	0	0	0	-6	
Salinity	0	0	0	0	0	0	0	0	0	0	0	0	0	
Flow at Vernalis	-1	-1	-1	-1	-2	-2	-3	-2	-3	0	0	-1		-17
Shallow Water Habitat	0	0	0	1	1	1	0	0	0	0	0	0		3
Food Supply	0	0	0	1	1	1	1	1	0	0	0	0		5
Ag Diversions	0	0	0	0	0	0	0	0	0	0	0	0		0
Adult Migration	na	na	na	na	na	na	na	na	na	na	na	na		0
Toxics (dilution/inputs)	*	*	*	*	*	*	*	*	*	*	*	*		0
													TOTAL	-18

ALTERNATIVE 3 (without storage)

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep		SUM
Entrainment	0	0	0	0	0	-1	0	0	-1	0	0	0		-2
													sum	
% Population Exposed	*	*	*	*	*	*	*	*	*	*	*	*	0	
Screen Efficiency/Predati	*	*	*	*	*	*	*	*	*	*	*	*	0	
Handling/Trucking Losse	*	*	*	*	*	*	*	*	*	*	*	*	0	
CCFB losses	*	*	*	*	*	*	*	*	*	*	*	*	0	
Interior Delta Survival	2	2	1	2	3	2	1	0	0	0	0	1		14
													sum	
Flow Distribution	1	1	1	2	3	3	2	2	3	0	0	1	19	
Upper Old River Barrier	1	1	0	0	0	0	1	1	0	0	0	0	4	
Predation in the Delta	0	0	0	0	0	-1	-1	-1	0	0	0	0	-3	
Temperature	0	0	0	0	0	0	-1	-2	-3	0	0	0	-6	
Salinity	0	0	0	0	0	0	0	0	0	0	0	0	0	
Flow at Vernalis	-1	-1	-1	-1	-2	-2	-3	-2	-3	0	0	-1		-17
Shallow Water Habitat	0	0	0	1	1	1	0	0	0	0	0	0		3
Food Supply	0	0	0	1	1	1	1	1	0	0	0	0		5
Ag Diversions	0	0	0	0	0	0	0	0	0	0	0	0		0
Adult Migration	na	na	na	na	na	na	na	na	na	na	na	na		0
Toxics (dilution/inputs)	*	*	*	*	*	*	*	*	*	*	*	*		0
													TOTAL	3

ALTERNATIVE 1 (with storage)

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	sum	SUM
Entrainment	0	0	0	-1	-2	-3	-1	-1	-2	0	0	0		-10
% Population Exposed	*	*	*	*	*	*	*	*	*	*	*	*	0	
Screen Efficiency/Predati	*	*	*	*	*	*	*	*	*	*	*	*	0	
Handling/Trucking Losse	*	*	*	*	*	*	*	*	*	*	*	*	0	
CCFB Losses	*	*	*	*	*	*	*	*	*	*	*	*	0	
Interior Delta Survival	0	0	-1	-3	-3	-4	-2	-3	-5	0	0	-1		-22
Flow Distribution	-1	-1	-1	-3	-3	-3	-1	-1	-2	0	0	-1	-17	
Upper Old River Barrier	1	1	0	0	0	0	1	1	0	0	0	0	4	
Predation in the Delta	0	0	0	0	0	-1	-1	-1	0	0	0	0	-3	
Temperature	0	0	0	0	0	0	-1	-2	-3	0	0	0	-6	
Salinity	0	0	0	0	0	0	0	0	0	0	0	0	0	
Flow at Vernalis	-1	-1	-1	-1	-2	-2	-3	-2	-3	0	0	-1		-17
Shallow Water Habitat	0	0	0	1	1	1	0	0	0	0	0	0		3
Food Supply	0	0	0	1	1	1	1	1	0	0	0	0		5
Ag Diversions	0	0	0	0	0	0	0	0	0	0	0	0		0
Adult Migration	na	na	na	na	na	na	na	na	na	na	na	na		0
Toxics (dilution/inputs)	*	*	*	*	*	*	*	*	*	*	*	*		0
													TOTAL	-41

ALTERNATIVE 2 (with storage)

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	sum	SUM
Entrainment	0	0	0	-1	-2	-3	-1	-1	-2	0	0	0		-10
% Population Exposed	*	*	*	*	*	*	*	*	*	*	*	*	0	
Screen Efficiency/Predati	*	*	*	*	*	*	*	*	*	*	*	*	0	
Trucking/Handling Losse	*	*	*	*	*	*	*	*	*	*	*	*	0	
CCFB Losses	*	*	*	*	*	*	*	*	*	*	*	*	0	
Interior Delta Survival	1	1	0	-1	0	-1	-1	-2	-2	0	0	0		-5
Flow Distribution	0	0	0	-1	0	0	0	0	1	0	0	0	0	
Upper Old River Barrier	1	1	0	0	0	0	1	1	0	0	0	0	4	
Predation in the Delta	0	0	0	0	0	-1	-1	-1	0	0	0	0	-3	
Temperature	0	0	0	0	0	0	-1	-2	-3	0	0	0	-6	
Salinity	0	0	0	0	0	0	0	0	0	0	0	0	0	
Flow at Vernalis	-1	-1	-1	-1	-2	-2	-3	-2	-3	0	0	-1		-17
Shallow Water Habitat	0	0	0	1	1	1	0	0	0	0	0	0		3
Food Supply	0	0	0	1	1	1	1	1	0	0	0	0		5
Ag Diversions	0	0	0	0	0	0	0	0	0	0	0	0		0
Adult Migration	na	na	na	na	na	na	na	na	na	na	na	na		0
Toxics (dilution/inputs)	*	*	*	*	*	*	*	*	*	*	*	*		0
													TOTAL	-24

ALTERNATIVE 3 (with storage)

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	sum	SUM
Entrainment	0	0	0	0	0	-1	0	0	-1	0	0	0		-2
% Population Exposed	*	*	*	*	*	*	*	*	*	*	*	*	0	
Screen Efficiency/Predati	*	*	*	*	*	*	*	*	*	*	*	*	0	
Handling/Trucking Losse	*	*	*	*	*	*	*	*	*	*	*	*	0	
CCFB losses	*	*	*	*	*	*	*	*	*	*	*	*	0	
Interior Delta Survival	2	2	1	2	3	2	1	0	0	0	0	1		14
Flow Distribution	1	1	1	2	3	3	2	2	3	0	0	1	19	
Upper Old River Barrier	1	1	0	0	0	0	1	1	0	0	0	0	4	
Predation in the Delta	0	0	0	0	0	-1	-1	-1	0	0	0	0	-3	
Temperature	0	0	0	0	0	0	-1	-2	-3	0	0	0	-6	
Salinity	0	0	0	0	0	0	0	0	0	0	0	0	0	
Flow at Vernalis	-1	-1	-1	-1	-2	-2	-3	-2	-3	0	0	-1		-17
Shallow Water Habitat	0	0	0	1	1	1	0	0	0	0	0	0		3
Food Supply	0	0	0	1	1	1	1	1	0	0	0	0		5
Ag Diversions	0	0	0	0	0	0	0	0	0	0	0	0		0
Adult Migration	na	na	na	na	na	na	na	na	na	na	na	na		0
Toxics (dilution/inputs)	*	*	*	*	*	*	*	*	*	*	*	*		0
													TOTAL	3

DIVERSION EFFECTS ON FISH

APPENDIX B

CALFED ALTERNATIVE EVALUATION FOR STRIPED BASS

DIVERSION EFFECTS ON FISH

CALFED ALTERNATIVE EVALUATION FOR STRIPED BASS NARRATIVE

Draft - June 23, 1998

Introduction-Evaluation Team and Process:

The CALFED task of evaluating diversion effects on fish was divided into species subcommittees. The striped bass subgroup met twice and evaluated the diversion impacts of the alternatives based on information provided in the CALFED Phase II report and recent operation studies.

The striped bass evaluation is based on a review by biologists with knowledge of the striped bass population and historic relationships of egg and larva distribution and abundance, young-of-the-year abundance, and adults in relation to estuarine conditions and historic changes. Participants on the work team are Stephani Spaar (Department of Water Resources), David Kohlhorst, Lee Miller, Kevan Urquhart, and Don Stevens (Department of Fish and Game). Elise Holland (Bay Institute) was a member of our team but was unable to attend the meetings when the matrices of diversion effects were developed. This report is the result of the interactions of this group.

Methods:

We completed matrices (pages B10-B17) for: existing conditions, no action conditions (projection of increased demand on existing facilities), common programs, diversion alternatives 1, 2, and 3 and full restoration. The matrices were used as a guide and checklist to assure our consideration of the relevant diversion issues. We adopted a scale of -5 to +5 to express the relative impact of effects identified in the matrix as major components that would affect striped bass in relation to water diversions. Evaluations were based on qualitative assessments of the degree to which operations affect the population. We used two CALFED operations draft studies to evaluate future operations (CALFED 1998). Entrainment impacts included predation in Clifton Court, losses related to screen inefficiencies, handling and release site mortality. However, these were not separately scored but were included in our evaluation. After the matrix scoring was completed, we assigned relative weight factors to each component of the matrix. We also limited the fall-winter periods to combinations of months which became self-weighting in the process since striped bass during these periods generally tend to be less vulnerable to diversions.

Existing conditions are the diversions as operated currently with the 1995 Water Quality Control Plan Delta Standards in effect. An evaluation of full restoration conditions relative to the existing conditions and alternative choices was made to assess the extent to which the striped bass population would be restored with the proposed alternatives. All matrices were completed using the CALFED operations studies provided. This was a judgmental process with no striped bass modeling, data analysis, or quantitative assessments because time constraints did not permit more rigor. In many cases we cannot be certain how the population might respond to the new conditions being proposed.

Results

The following questions were evaluated.

1. Which life stages are most sensitive to diversion effects under no action and alternatives 1, 2, and 3? When and where are they most affected?

Existing Conditions

Diversions in the Delta have had a major impact on the striped bass population whose nursery area historically has been the Delta and Suisun Bay. (Chadwick et al. 1977, Stevens, et al. 1985, IESP 1987, Department of Fish and Game 1992). The decline in both the young of the year (YOY) measure of abundance (38 mm index) and adults have been linked to the effects of entrainment losses in the Delta. Diversion effects on striped bass and other fish were empirically demonstrated in 1977, a severe drought year, when flows were so low that export pumping was minimal or ceased for much of the year because of water quality problems related to low freshwater inflow. As a result there was an accumulation of striped bass in the Delta made evident by the large number of striped bass salvaged when export pumping did resume when Delta inflow increased in December. Such accumulations of fish in the Delta were not evident in either 1976 or 1978, years when export pumping was not curtailed in the summer (Table 1).

Table 1. Export pumping rates and delta smelt and striped bass salvage by the State Water Project (SWP) in 1976, 1977 and 1978. Data prepared for CALFED by H. K.Chadwick 1998.

	1976-1977			1977-1978			1978-1979		
	SWP Pumping-00's cfs	Delta smelt 000's	striped Bass 000's	SWP Pumping 00's cfs	Delta Smelt 000's	Striped Bass 000's	SWP Pumpin g-00's cfs	Delta Smelt 000's	Striped Bass 000's
May	6	102	16	11	3	0	9	4	1
June	3	277	717	3	3	53	33	36	633
July	3	371	639	3	43	367	34	1	1,115
Aug	21	68	156	2	6	12	40	2	307
Sept	35	1	13	2	18	1	35	0	18
Oct	14	0	2	1	3	0	20	0	173
Nov	16	0	32	9	0	22	22	0	171
Dec	10	0	20	22	55	63	27	1	172
Jan	33	7	58	60	134	590	13	0	34
Feb	19	2	10	61	54	306	16	1	8

More recent analyses also support these findings. Recently Kimmerer, et al. manuscript, suggests that density-dependent survival may moderate the effects of flows and diversions on year class strength. While relative year class strength often changes between YOY and

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recruitment at age 3, density-dependent survival does not fully compensate for lower numbers of YOY striped bass. The adult population was 1.8 million in early 1970's and has declined to about 0.5 to 0.7 million in the 1990's. This decline in adults is consistent with the general declines in egg abundance and the 38-mm index of young abundance. Compensation is insufficient to offset the decline in egg production which has ranged from 319 billion in 1969, to 31 billion, in 1996. Hence, there has been an order of magnitude decline in egg production versus only a 2/3 decline in the number of adults. Kimmerer, et al., manuscript, states "the median losses to pumping were estimated at 33 percent, a substantial fraction of the total mortality and losses were often much higher."

The Oakridge National Laboratory Individual Based Model results (draft report is in preparation by Kenny Rose) indicate that diversions and food supply variables together account for the decline in striped bass. However, if only diversions were set at pre-bass decline levels in the model, the population would recover to a stable population of about 1.5 million adults which, though not the historic measured high of 1.8 million, is evidence of the importance of diversions in driving the striped bass population decline. Food by itself in the model caused only a decline to 1.5 million adults but when both food and diversions are included the population declined to 0.5 million. These model runs were made with density-dependence accounted for in the model.

Apparent adult mortality has also increased in recent years and increased ocean migrations which result in straying to other estuaries and possibly intermittent returning to this estuary to spawn has been suggested as an explanation by Bennett, ms. The decline in egg production appears to be a combination of fewer adults due to less recruitment and a greater decline in older fish due to higher mortality, although the cause of the increase in mortality is unknown.

No Action.

Striped bass eggs and larva and juveniles are the life stages directly impacted by water diversions in the Delta during the first year of life from April through the fall and sometimes during winter. The impact on eggs, larvae and young juveniles occurs from April to July with further impacts on juveniles through the summer and fall. These impacts would continue under the No Action Alternative. Total exports under the No Action Alternative during the spawning and nursery season are roughly the same as average existing conditions (CALFED 1998, Appendices A, E). Although average annual exports for this alternative are 6.5 % higher than existing exports, most of this increase occurs from August to March. The added impact on striped bass during this period tends to be relatively small in wet years and greater in dry and critical years because of longer fish residence time in the Delta when flows are low.

It is unclear whether increased exports over current levels would further deplete the population of young striped bass in the Delta, since they may already be nearly depleted there under current export levels in dry and critical years. Under current conditions the population is likely to continue to decline in the absence of a hatchery stocking program (Department of Fish and Game 1998). In recent years, young striped bass abundance has remained low despite higher than average delta outflows and low export rates, both of which are conducive to strong year classes. The most apparent cause is the continuing decline in egg production caused by average lower recruitment since the 1970's due to entrainment losses and relatively fewer, older, more fecund adults as a result of lower recruitment and an increase in adult mortality rates.

Alternative 1.

Under Alternative 1, entrainment of eggs, larvae, and juveniles in the south Delta would continue, but additional juveniles would be salvaged because of improvements in fish facilities and elimination of Clifton Court pre-screen losses. The closure of the cross channel gates through the spawning season from April to June for winter-run chinook salmon protection, would reduce the diversion of Sacramento River striped bass eggs and larvae in comparison to periods when the cross channel gates were open in years before the winter-run criteria went into effect. However, closing these gates may lead to greater negative flows in the San Joaquin River. As in the past, eggs and larvae would move across the Delta from the Sacramento River through Georgiana and Three-mile sloughs and some would be entrained at the export facilities.

Alternative 2.

Under Alternative 2, increased numbers of eggs and larvae would be diverted and entrained from the Sacramento River because fish screens at the Hood diversion would be inadequate to screen these stages. At the Clifton Court diversion, eggs, larvae, and juveniles would continue to be entrained; additional juveniles would be salvaged because of improvements in fish facilities and elimination of Clifton Court pre-screen losses.

However, adults would be adversely affected because they would be attracted by the high proportion of Sacramento water in the Mokelumne River and hence blocked from completing their migration by the fish screen at Hood. This problem requires a feasible means of fish passage. Apparently, it is possible to trap and pass striped bass over such structures but whether it is feasible, advisable and cost effective to move several hundred thousand striped bass around a structure in a short time, remains to be explored. If trapped adults spawn in the Mokelumne River in response to rising temperatures before they are passed around the fish screen, most of their progeny would be highly vulnerable to Delta diversions, although tidal dispersion at the junction of the San Joaquin River and Mokelumne River might enable some to escape initial entrainment. Estimates of the percentage reduction in the population of striped bass eggs and larvae in the Delta are substantial under existing conditions. Estimates of reduction in low flow years range from 73.5 to 99.6 percent (DFG 1992). Population reduction would likely increase if Sacramento River bound fish spawn in the Mokelumne River and that water goes directly to the export pumps.

It is unknown what proportion of the population might use this channel to attempt to access the Sacramento River. If flows diverted at Hood are a large proportion of the Sacramento flow, as might occur in dry years, more fish might be attracted to the Mokelumne River as a corridor to the spawning grounds. Some striped bass tagged and released in the San Joaquin River are commonly recaptured within a few weeks from the Sacramento River above Sacramento, but it is unknown which pathways from the San Joaquin River to the Sacramento River are most important.

Alternative 3.

Increased numbers of eggs and larvae could be diverted and entrained from the Sacramento River because fish screens at the Hood diversion would be inadequate to screen these stages. However, a higher proportion of the juveniles entrained would be salvaged because of improvements in fish facilities and elimination of Clifton Court pre-screen losses. The magnitude of the diversion of eggs and larvae from both the Sacramento and San Joaquin rivers, as well as eggs, larvae and juveniles from the San Joaquin, depends on operation of the facilities. For example, a temporary reduction in diversion at Hood during the striped bass spawning season would reduce diversion of eggs and larva from the Sacramento River and provide transport flow to move young bass to the nursery areas downstream. If diversions are not curtailed entrainment of egg and larva will be high and transport flows will likely be inadequate. Adult migrations would not be affected as for Alternative 2 because the facility is isolated. When diversion occurs in the south Delta, some entrainment would continue for eggs, larvae, and juveniles from the San Joaquin River and through other Delta channels. However, because QWEST flows would be improved over existing conditions and less water would be diverted from the south Delta, we expect less entrainment of striped bass and improvement of nursery habitat in the Delta.

2. Can diversion effects in the South Delta be offset by habitat improvements and other common program actions?

Striped bass can use various habitats to rear, including shallow water. Any improvements in habitat such as an increase in tidal marshes in Suisun Bay, San Pablo Bay or in other areas secure from entrainment effects could help striped bass; however, there is no way to determine, a priori, if such habitat change would offset entrainment losses and indirect mortality from transport flow reductions on the Sacramento River. As stated above, south Delta diversions have a major impact on the population so habitat improvements would need to have a large impact to offset existing conditions.

Reduction in toxicants may improve striped bass survival, but toxicants have not been identified as a major controlling factor for the striped bass population. Hence, population increases resulting from this program would likely be small.

Some common programs may adversely affect striped bass and other fish populations if nutrients and turbidity are reduced. For example, if nutrients, carbon input, and primary production are decreased this would reduce the food supply for fish. Turbidity reduction could result in increased predation on young striped bass and other fish. While these common programs are difficult to evaluate, some would likely be an improvement over existing conditions.

3. To what extent can alternatives 1, 2, and 3 offset diversions effects as presently configured?

All three alternatives screen the intake to Clifton Court Forebay which reduces predation and other losses now occurring in Clifton Court. The No Action choice would continue these losses. Screening of agriculture diversions would reduce losses of some young striped bass which are beyond the egg and larva stage.

Alternative 1.

Alternative 1 offers marginally improved conditions for striped bass compared to existing conditions by elimination of predation on young striped bass in Clifton Court Forebay. However, striped bass in the Delta would still be exposed to large potential entrainment losses due to screen inefficiencies, handling mortality, and indirect losses. This alternative maintains flows in the Sacramento River below Hood as occurs under present conditions, providing for faster transport of striped bass out of the river and into the lower river and Suisun Bay than either Alternatives 2 or 3. Striped bass survival between egg and larva stages increases with increased river flow (IESP 1994).

Alternative 2.

Because the Hood diversion would reduce transport flows for larvae, potentially result in significant numbers of adults spawning in the Mokelumne River, and entrain large numbers of eggs and larvae from the Sacramento River, this alternative would provide worse conditions for striped bass than existing diversion conditions. The extent of these impacts is uncertain given the unknowns associated with the above. How these facilities are operated to minimize impacts during the spawning season is important.

If only a few adults were blocked from migrating to the Sacramento River at Hood, Alternative 2 would likely decrease the entrainment of striped bass in the South Delta by creating more positive net flows in the San Joaquin River. Operation studies indicate that net San Joaquin River flows at Antioch would be positive for all months of the year and in April-July would be about double the No Action conditions or conditions under Alternative 1. However, these flows are still small relative to the tidal volume. On average, reverse flows would no longer occur on the San Joaquin River (based on operations studies: QWEST, 1921-1994; Flow at Antioch, 1975-1991).

Alternative 3.

The use of Alternative 3 in lieu of existing conditions for times of the year other than the striped bass spawning period would greatly reduce the entrainment losses now occurring in the south Delta. Additionally, because it is an isolated facility, it would not attract adult fish and this obviates the need to deal with the problem of passing fish past a fish screen at Hood as in Alternative 2. The diversion of eggs and larvae during the spawning season and reduced transport flows in the Sacramento River below Hood would decrease the survival of eggs and larvae in that river reach. If the facility were operated to minimize such diversions when striped bass spawn and south Delta diversions were also minimized during the spawning and nursery period, this would provide greatly improved conditions for striped bass. Positive flows in the San Joaquin River would be good for striped bass spawning in the San Joaquin River; it would move them west to better nursery conditions and away from entrainment and improve the Delta as nursery habitat for striped bass. This alternative scored highest in the matrix exercise.

5. What is the risk and chances of success of species recovery for each alternative?

The striped bass population has been declining. The adult population is affected by reduced recruitment as a result of early life stage losses without sufficient density-dependent survival (compensation) to maintain the numbers of adults that were historically present. Although some compensation is apparently occurring between the summer abundance in the first year of life and recruitment at age 3, the population of adults, which numbered 1.8 million in the early 1970's, has declined to about 700,000 presently. Recovery cannot occur under the No Action Alternative. Alternatives 1 and 2 appear to exacerbate present striped bass population stresses related to using the Delta as a water export conduit. Alternative 3 still falls short of full restoration to historic population levels (see Appendix matrix, page 8), largely because water demands exclude achievement of full restoration conditions. Alternative 3, if operated in a manner which minimized entrainment of young striped bass, provides the best opportunity for some restoration of the population.

6. What increment of protection or improvement for fish species will be provided by other programs such as the Central Valley Project Improvement Act(CVPIA), biological opinions, etc.?

This is difficult to evaluate since no water has been firmly committed to any striped bass restoration scenario. It is unlikely that the 800,000 acre feet of water allocated under the CVPIA doubling of anadromous fish will cause a doubling of striped bass given the existing export conditions and diversion impacts.

7. **What degree of benefit and impact will the common programs provide?**

The common programs will likely provide some benefits for young striped bass, but these are difficult to evaluate. Screening of small Agricultural diversions would reduce mortality of young striped bass. Planned increases in the amount of tidal marsh habitat for nursery areas adjacent to Suisun Bay and San Pablo Bay could increase survival of young striped bass. Reducing point and non-point sources of toxic chemicals and metals could improve conditions for all life stages to some degree, however, present population effects of toxicants have not been demonstrated. Reduction of organic input and decreasing turbidity may adversely affect striped bass production.

8. **What are the direct and indirect effects on fish populations resulting from each alternative and what is the expected response of the populations to these effects?**
Covered in answers to questions 1-6.

9. **What Sacramento River flow is required below a Hood diversion to protect salmon, striped bass and delta smelt?**
Transport flows to move striped bass into the estuary are important. When large numbers of striped bass eggs and larvae are moving down the Sacramento River, diversion should stop or be minimized to reduce the impact of entrainment and to assure sufficient transport flow to promote the survival of larvae. We recommend that flows be maintained at a high enough level to transport eggs to Collinsville to Rio Vista reach of the river within 4 days after passing Hood. Reduction of flows below Hood to less than what now occurs when I street flows are 13,000 cfs or greater would be detrimental to young striped bass.

10. **What survival rate can be expected for striped bass eggs and larvae and delta smelt passing through Sacramento River screens and pumps in Alternative 2?**
We would expect that most striped bass eggs and larvae would be entrained with water diverted at Hood and channeled to the pumping plants; therefore, survival would be very low. Some would likely be caught in the tidal volume and move back and forth in the San Joaquin River and of these some might avoid entrainment by moving beyond the influence of the pumps, depending on San Joaquin River net flows and dispersion in the lower San Joaquin River. However, as previously indicated, net flows are low relative to the tidal volume which suggests that residence time within the influence of the pumps will be long. Modeling of the hydrodynamics might be helpful to estimating the proportion of striped bass larvae and juveniles lost to pumping.

11. **Should there be a screen on the Sacramento River intake of Alternative 2?**
A screen for striped bass eggs and larvae, if feasible, would likely be very expensive and difficult to maintain in a debris free state. A screen for salmon juveniles or young striped bass would also be a negative factor if it traps striped bass adults migrating through the Mokelumne River to the Sacramento River spawning grounds.

12. What are the logical stages for a preferred alternative?
Alternative 3 is the preferred alternative for striped bass. It is not clear how this could be built in stages based on biological considerations.

Uncertainties

There are many uncertainties in this evaluation, both large and small. Even with further data exploration, there is much that would remain speculative in our assessment of potential benefits and detriments. First, there is the uncertainty regarding how much striped bass entrainment losses will be reduced and access to nursery areas enhanced with positive downstream flows rather than reverse flows in the lower San Joaquin River. Similarly, when Sacramento River flows necessary for larva transport are greatly reduced below Hood, how much will this affect the survival of striped bass left in the river? At this location, transport flows obviously become more important in years of low inflow. The proportion of the adults that would use the Mokelumne River as a migration corridor to the Sacramento River spawning ground is unknown. If that proportion is small, it will have a minor effect, but if it is large, it will have a major negative impact.

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Matrix for Calfed

CALFED Alternatives evaluation for striped bass -page 1

Diversion Effects on Striped Bass-Existing conditions assumes Delta Accord

Effects	wt.	Oct-Nov	Dec- Mar	Apr	May	June	July	Aug	Sep	sum	comments
Entrainment	10	-1	-1	-2	-3	-3	-4	-2	-1		June to Aug more predation on juveniles.
Predation mortality-CCF + return											
Entrainment losses											
Handling mortality											
Food supply	3	0	0	0	0	-1	-1	-1	0		Diversion effects on zooplankton appear small
Shallow/inshore habitat- offsetting div.	1	0	0	0	0	0	0	0	0		
Water quality (toxics)	1	0	0	0	0	-1	0	0	0		
WQ (salinity) affecting SJR spawning	1	0	0	-1	-1	0	0	0	0		
Agricultural diversions	3	0	0	-1	-2	-2	-1	0	0		Diversions vary with water year type.
Hydrodynamics-Sacramento R. trans	3	0	0	-1	-1	-1	0	0	0		
Hydrodynamics-San Joaquin flow	3	0	0	-1	-1	-2	-2	-2	-1		Diversions vary with water year type.
Hydrodynamic- Xdel fl- G. sl and 3 mi.	3	0	0	-1	-1	-1	0	-1	0		
Unweighted total		-1	-1	-7	-9	-11	-8	-6	-2	-45	
life stage		juv	juv	e & l	e & l	e & l, juv	l & juv	juv	juv		

Diversion Effects on Striped Bass- No Action

Effects		Oct-Nov	Dec- Mar	Apr	May	June	July	Aug	Sep		comments
Entrainment	10	-1	-2	-2	-3	-3	-4	-2	-1		shaded cells indicate change from existing conditions
Predation mortality-CCF											
Entrainment losses											
Handling mortality											
Food supply	3	0	0	0	0	-1	-1	-1	0		
Shallow/ nearshore habitat	1	0	0	0	0	0	0	0	0		
Water quality (toxics)	1	0	0	0	0	-1	0	0	0		
WQ (salinity) affecting SJR spawning	1	0	0	-1	-1	0	0	0	0		
Agricultural diversions	3	0	0	-1	-2	-2	-1	0	0		
Hydrodynamics-Sacramento R. trans	3	0	0	-1	-1	-1	0	0	0		
Hydrodynamics-San Joaquin flow	3	0	0	-1	-1	-2	-2	-2	-1		
Hydrodynamic- Xdel fl- G. sl and 3 mi.	3	0	0	-1	-1	-1	0	-1	0		
Unweighted total		-1	-2	-7	-9	-11	-8	-6	-2	-46	
life stage		juv	juv	e & l	e & l	e & l, juv	l & juv	juv	juv		

CALFED Alternatives evaluation for striped bass -page 2

Diversion Effects on Striped Bass-common programs

Effects	wt.	Oct-Nov	Dec- Mar	Apr	May	June	July	Aug	Sep		comments
Entrainment	10	0	0	0	0	0	0	0	0		
Predation mortality-CCF											
Entrainment losses											
Handling mortality											
Food supply	3	0	0	0	0	0	0	0	0		
Shallow/inshore habitat- offsetting div.	1	0	0	0	0	0	0	0	0		difficult to assess for striped bass/ need more info.
Water quality (toxics and nutrients)	1	0	0	0	0	0	0	0	0		water quality for drinking water not necessarily good for fish
WQ (salinity) affecting SJR spawning	1	0	0	0	0	0	0	0	0		
Agricultural diversions	3	0	0	0	0	0	0	0	0		
Hydrodynamics-Sacramento R. trans	3	0	0	0	0	0	0	0	0		
Hydrodynamics-San Joaquin flow	3	0	0	0	0	0	0	0	0		
Hydrodynamic- Xdel fl- G. sl and 3 mi.	3	0	0	0	0	0	0	0	0		
Unweighted total		0	0	0	0	0	0	0	0	0	
life stage		juv	juv	e & l	e & l	e & l, juv	l & juv	juv	juv		

Diversion Effects on Striped Bass- Alternative 1

Effects		Oct-Nov	Dec- Mar	Apr	May	June	July	Aug	Sep		comments
Entrainment	10	-1	-1	-2	-3	-2	-3	-1	-1		shaded cells indicate change from existing conditions
Predation mortality-CCF											
Entrainment losses											
Handling mortality											
Food supply	3	0	0	0	0	-1	-1	-1	0		
Shallow/ nearshore habitat	1	0	0	0	0	0	0	0	0		
Water quality (toxics)	1	0	0	0	0	-1	0	0	0		
WQ (salinity) affecting SJR spawning	1	0	0	-1	-1	0	0	0	0		
Agricultural diversions	3	0	0	-1	-2	-2	-1	0	0		
Hydrodynamics-Sacramento R. trans	3	0	0	-1	-1	-1	0	0	0		
Hydrodynamics-San Joaquin flow	3	0	0	-1	-1	-2	-2	0	0		
Hydrodynamic- Xdel fl- G. sl and 3 mi.	3	0	0	-1	-1	-1	0	-1	0		
Unweighted total		-1	-1	-7	-9	-10	-7	-3	-1	-39	
life stage		juv	juv	e & l	e & l	e & l, juv	l & juv	juv	juv		

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CALFED Alternatives evaluation for striped bass -page 3

Diversion Effects on Striped Bass-Alternative 2

Effects	wt.	Oct-Nov	Dec- Mar	Apr	May	June	July	Aug	Sep		comments
Entrainment	10	-1	-1	-3	-4	-2	-4	-1	-1		Losses due to Mokelumne spawning location
Predation mortality-CCF & release											shaded cells indicate change from existing conditions
Entrainment losses											
Handling mortality											
Food supply	3	0	0	0	0	-1	-1	-1	0		
Shallow/inshore habitat- offsetting div.	1	0	0	0	0	0	0	0	0		No effect on striped bass predicted. High uncertainty.
Water quality (toxics)	1	0	0	0	0	-1	0	0	0		
WQ (salinity) affecting SJR spawning	1	0	0	-1	-1	0	0	0	0		
Agricultural diversions	3	0	0	-1	-2	-2	-1	0	0		
Hydrodynamics-Sacramento R. trans	3	0	0	-2	-4	-3	0	0	0		
Hydrodynamics-San Joaquin flow	3	0	0	2	1	1	-1	-1	0		Positive downstream flows April-July; Lower flows in July-Aug
Hydrodynamic- Xdel fl- G. sl and 3 mi.	3	0	0	-3	-3	-3	0	-1	0		adults spawning in Mokelumne River
Unweighted total		-1	-1	-8	-13	-11	-7	-4	-1	-46	
life stage		juv	juv	e & l	e & l	e & l, juv	l & juv	juv	juv		adults affected by screen barrier to spawning areas

Diversion Effects on Striped Bass- Alternative 3.

Effects		Oct-Nov	Dec- Mar	Apr	May	June	July	Aug	Sep		comments
Entrainment	10	2	2	1	3	-1	4	3	2		shaded cells indicate change from existing conditions
Predation mortality-CCF & release											
Entrainment losses											
Handling mortality											
Food supply	3	0	0	0	0	-1	-1	-1	0		
Shallow/ nearshore habitat	1	0	0	0	0	0	0	0	0		
Water quality (toxics)	1	0	0	0	0	-1	0	0	0		
WQ (salinity) affecting SJR spawning	1	0	0	-1	-1	0	0	0	0		
Agricultural diversions	3	0	0	-1	-2	-2	-1	0	0		
Hydrodynamics-Sacramento R. trans	3	0	0	-2	-4	-3	0	0	0		
Hydrodynamics-San Joaquin flow	3	0	0	2	1	1	1	1	0		
Hydrodynamic- Xdel fl- G. sl and 3 mi.	3	0	0	-1	-1	-1	0	0	0		
Unweighted total		2	2	-2	-8	-6	3	3	2	-4	
life stage		juv	juv	e & l	e & l	e & l, juv	l & juv	juv	juv		

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CALFED Alternatives evaluation for striped bass -page 4

Diversion Effects on Striped Bass - Restoration conditions

Effects	wt.	Oct-Nov	Dec- Mar	Apr	May	June	July	Aug	Sep		comments
Entrainment	10	2	2	5	5	5	5	4	3		June to Aug more predation on juveniles.
Predation mortality-CCF + return											shaded cells indicate change from existing conditions
Entrainment losses											
Handling mortality											
Food supply	3	1	0	2	2	2	2	2	1		
Shallow/inshore habitat- offsetting div.	1	0	0	0	0	0	0	0	0		
Water quality (toxics)	1	1	1	1	1	1	1	1	1		
WQ (salinity) affecting SJR spawning	1	0	0	1	1	1	0	0	0		
Agricultural diversions	3	0	0	-1	-2	-2	-1	0	0		
Hydrodynamics-Sacramento R. trans	3	0	0	3	3	3	0	0	0		
Hydrodynamics-San Joaquin flow	3	0	0	2	2	2	2	2	0		
Hydrodynamic- Xdel fl- G. sl and 3 mi.	3	0	0	1	1	1	0	0	0		
Unweighted total		4	3	14	13	13	9	9	5	70	
life stage		juv	juv	e & l	e & l	e & l, juv	l & juv	juv	juv		

E-003561

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Matrix for Calfed

CALFED Alternatives evaluation for striped bass -page 5--Weighted Results

Diversion Effects on Striped Bass-Existing conditions assumes Delta Accord

Effects	wt.	Oct-Nov	Dec- Mar	Apr	May	June	July	Aug	Sep	sum	comments
Entrainment	10	-10	**-10**	-20	-30	-30	-40	-20	-10	-170	June to Aug more predation on juveniles.
Predation mortality-CCF + return											
Entrainment losses											
Handling mortality											
Food supply	3	0	0	0	0	-3	-3	-3	0	-9	Diversion effects on zooplankton appear small
Shallow/inshore habitat- offsetting div.	1	0	0	0	0	0	0	0	0	0	
Water quality (toxics)	1	0	0	0	0	-1	0	0	0	-1	
WQ (salinity) affecting SJR spawning	1	0	0	-1	-1	0	0	0	0	-2	
Agricultural diversions	3	0	0	-3	-6	-6	-3	0	0	-18	Diversions vary with water year type.
Hydrodynamics-Sacramento R. trans	3	0	0	-3	-3	-3	0	0	0	-9	
Hydrodynamics-San Joaquin flow	3	0	0	-3	-3	-6	-6	-6	-3	-27	Diversions vary with water year type.
Hydrodynamic- Xdel fl- G. sl and 3 mi.	3	0	0	-3	-3	-3	0	-3	0	-12	
Weighted total		-10	-10	-33	-46	-52	-52	-32	-13	-248	
life stage		juv	juv	e & l	e & l	e & l, juv	l & juv	juv	juv		

Diversion Effects on Striped Bass- No Action--Weighted Results

Effects		Oct-Nov	Dec- Mar	Apr	May	June	July	Aug	Sep	sum	comments
Entrainment	10	-10	-20	-20	-30	-30	-40	-20	-10	-180	shaded cells indicate change from existing conditions
Predation mortality-CCF											
Entrainment losses											
Handling mortality											
Food supply	3	0	0	0	0	-3	-3	-3	0	-9	
Shallow/ nearshore habitat	1	0	0	0	0	0	0	0	0	0	
Water quality (toxics)	1	0	0	0	0	-1	0	0	0	-1	
WQ (salinity) affecting SJR spawning	1	0	0	-1	-1	0	0	0	0	-2	
Agricultural diversions	3	0	0	-3	-6	-6	-3	0	0	-18	
Hydrodynamics-Sacramento R. trans	3	0	0	-3	-3	-3	0	0	0	-9	
Hydrodynamics-San Joaquin flow	3	0	0	-3	-3	-6	-6	-6	-3	-27	
Hydrodynamic- Xdel fl- G. sl and 3 mi.	3	0	0	-3	-3	-3	0	-3	0	-12	
Weighted total		-10	-20	-33	-46	-52	-52	-32	-13	-258	
life stage		juv	juv	e & l	e & l	e & l, juv	l & juv	juv	juv		

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CALFED Alternatives evaluation for striped bass -page 6.

Diversion Effects on Striped Bass-common programs --Weighted Results

Effects	wt.	Oct-Nov	Dec- Mar	Apr	May	June	July	Aug	Sep	sum	comments
Entrainment	10	0	0	0	0	0	0	0	0	0	shaded cells indicate change from existing conditions
Predation mortality-CCF											
Entrainment losses											
Handling mortality											
Food supply	3	0	0	0	0	0	0	0	0	0	
Shallow/inshore habitat- offsetting div.	1	0	0	0	0	0	0	0	0	0	difficult to assess for striped bass/ need more info.
Water quality (toxics and nutrients)	1	0	0	0	0	0	0	0	0	0	water quality for drinking water not necessarily good for fish
WQ (salinity) affecting SJR spawning	1	0	0	0	0	0	0	0	0	0	
Agricultural diversions	3	0	0	0	0	0	0	0	0	0	
Hydrodynamics-Sacramento R. trans	3	0	0	0	0	0	0	0	0	0	
Hydrodynamics-San Joaquin flow	3	0	0	0	0	0	0	0	0	0	
Hydrodynamic- Xdel fl- G. sl and 3 mi.	3	0	0	0	0	0	0	0	0	0	
Weighted total		0	0	0	0	0	0	0	0	0	
life stage		juv	juv	e & l	e & l	e & l, juv	l & juv	juv	juv		

Diversion Effects on Striped Bass- Alternative 1--Weighted Results

Effects		Oct-Nov	Dec- Mar	Apr	May	June	July	Aug	Sep	sum	comments
Entrainment	10	-10	-10	-20	-30	-20	-30	-10	-10	-140	shaded cells indicate change from existing conditions
Predation mortality-CCF											
Entrainment losses											
Handling mortality											
Food supply	3	0	0	0	0	-3	-3	-3	0	-9	
Shallow/ nearshore habitat	1	0	0	0	0	0	0	0	0	0	
Water quality (toxics)	1	0	0	0	0	-1	0	0	0	-1	
WQ (salinity) affecting SJR spawning	1	0	0	-1	-1	0	0	0	0	-2	
Agricultural diversions	3	0	0	-3	-6	-6	-3	0	0	-18	
Hydrodynamics-Sacramento R. trans	3	0	0	-3	-3	-3	0	0	0	-9	
Hydrodynamics-San Joaquin flow	3	0	0	-3	-3	-6	-6	0	0	-18	
Hydrodynamic- Xdel fl- G. sl and 3 mi.	3	0	0	-3	-3	-3	0	-3	0	-12	
Weighted total		-10	-10	-33	-46	-42	-42	-16	-10	-209	
life stage		juv	juv	e & l	e & l	e & l, juv	l & juv	juv	juv		

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Diversion Effects on Striped Bass-Alternative 2 --Weighted Results

Effects	wt.	Oct-Nov	Dec- Mar	Apr	May	June	July	Aug	Sep	sum	comments
Entrainment	10	-10	-10	-30	-40	-20	-40	-10	-10	-170	June to Aug more predation on juveniles.
Predation mortality-CCF & release											shaded cells indicate change from existing conditions
Entrainment losses											
Handling mortality											
Food supply	3	0	0	0	0	-3	-3	-3	0	-9	
Shallow/inshore habitat- offsetting div.	1	0	0	0	0	0	0	0	0	0	No effect on striped bass predicted. High uncertainty.
Water quality (toxics)	1	0	0	0	0	-1	0	0	0	-1	
WQ (salinity) affecting SJR spawning	1	0	0	-1	-1	0	0	0	0	-2	
Agricultural diversions	3	0	0	-3	-6	-6	-3	0	0	-18	
Hydrodynamics-Sacramento R. trans	3	0	0	-6	-12	-9	0	0	0	-27	
Hydrodynamics-San Joaquin flow	3	0	0	6	3	3	-3	-3	0	6	Positive downstream flows April-July;+K22 Lower flows in July-
Hydrodynamic- Xdel fl- G. sl and 3 mi.	3	0	0	-9	-9	-9	0	-3	0	-30	adults spawning in Mokelumne River
Weighted total		-10	-10	-43	-65	-45	-49	-19	-10	-251	
life stage		juv	juv	e & l	e & l	e & l, juv	l & juv	juv	juv		adults affected by screen barrier to spawning areas

Diversion Effects on Striped Bass- Alternative 3 --Weighted Results

Effects		Oct-Nov	Dec- Mar	Apr	May	June	July	Aug	Sep	sum	comments
Entrainment	10	20	20	-10	-30	-10	40	30	20	80	shaded cells indicate change from existing conditions
Predation mortality-CCF & release											
Entrainment losses											
Handling mortality											
Food supply	3	0	0	0	0	-3	-3	-3	0	-9	
Shallow/ nearshore habitat	1	0	0	0	0	0	0	0	0	0	
Water quality (toxics)	1	0	0	0	0	-1	0	0	0	-1	
WQ (salinity) affecting SJR spawning	1	0	0	-1	-1	0	0	0	0	-2	
Agricultural diversions	3	0	0	-3	-6	-6	-3	0	0	-18	
Hydrodynamics-Sacramento R. trans	3	0	0	-6	-12	-9	0	0	0	-27	
Hydrodynamics-San Joaquin flow	3	0	0	6	3	3	3	3	0	18	
Hydrodynamic- Xdel fl- G. sl and 3 mi.	3	0	0	3	3	3	0	0	0	9	
Weighted total		20	20	-11	-43	-23	37	30	20	50	
life stage		juv	juv	e & l	e & l	e & l, juv	l & juv	juv	juv		

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Diversion Effects on Striped Bass - Restoration conditions --Weighted Results

Effects	wt.	Oct-Nov	Dec- Mar	Apr	May	June	July	Aug	Sep	sum	comments
Entrainment	10	20	20	50	50	50	50	40	30	310	June to Aug more predation on juveniles.
Predation mortality-CCF + return											shaded cells indicate change from existing conditions
Entrainment losses											
Handling mortality											
Food supply	3	3	0	6	6	6	6	6	3	36	
Shallow/inshore habitat- offsetting div.	1	0	0	0	0	0	0	0	0	0	
Water quality (toxics)	1	1	1	1	1	1	1	1	1	8	
WQ (salinity) affecting SJR spawning	1	0	0	1	1	1	0	0	0	3	
Agricultural diversions	3	0	0	-3	-6	-6	-3	0	0	-18	
Hydrodynamics-Sacramento R. trans	3	0	0	9	9	9	0	0	0	27	
Hydrodynamics-San Joaquin flow	3	0	0	6	6	6	6	6	0	30	
Hydrodynamic- Xdel fl- G. sl and 3 mi.	3	0	0	3	3	3	0	0	0	9	
Weighted total		24	21	73	70	70	60	53	34	405	
life stage		juv	juv	e & l	e & l	e & l, juv	l & juv	juv	juv		

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DIVERSION EFFECTS ON FISH

APPENDIX C

CALFED ALTERNATIVE EVALUATION FOR DELTA SMELT

DIVERSION EFFECTS ON FISH

CALFED ALTERNATIVE EVALUATION FOR DELTA SMELT NARRATIVE

Draft - June 12, 1998

The delta smelt team consists of Michael Thabault, U.S. Fish and Wildlife Service, Larry Brown, U.S. Bureau of Reclamation, Dale Sweetnam, Department of Fish and Game, and Chuck Hanson, State Water Contractors. Those who participated in the creation of the first draft of the matrices include Michael Thabault, Larry Brown, and Dale Sweetnam.

The scale of each matrix box (pages C24-C29) ranges from +3 to -3 which expresses the relative impact of the effects identified that would affect delta smelt in relation to water diversions. Entries were based on a qualitative discussion of the degree to which operations or proposed operations impact the delta smelt population. The values in each box represent the combination of two estimates on the part of the Team: 1) the potential effect on the delta smelt population if exposure occurs, and 2) the probability that the population will be exposed. Therefore, caution should be used in interpretation of the matrix values. For example, exposure to toxicants includes the likelihood that fish will be exposed in addition to a judgement on the possible effects to the individuals that experience the exposure.

The delta smelt matrices were divided into "wet years" and "dry years" because distribution is strongly tied to hydrologic conditions and the effects (positive or negative) of potential actions in the delta potentially would be dampened in "wet years". The differences between the magnitude of the effects in wet and dry years is discussed in the narrative.

Definitions and Assumptions

Entrainment: Entrainment is defined as the direct effects of entrainment of delta smelt at the Cenral Valley Project and State Water Project pumping plants. Agricultural diversions are treated separately below. Consideration of other large diversions was not included in the charge to the group. Also, such consideration would require documentation and model runs for any changes in operation considered as part of CALFED or possible interactions of present operations with changes in Delta conditions that would result from the CALFED alternatives. The direct effects considered are: 1) entrainment and loss through export; 2) predation in Clifton Court Forebay and any other predation related to screens; and 3) losses due to handling of fish at fish salvage facilities. The entrainment score represents an overall effect of the three factors. The matrix includes rows for the three factors but the three rows may not necessarily add up to the total effect score assigned to entrainment. The extra scores are meant to indicate the relative importance of the various factors included in entrainment.

Hydrodynamics: Hydrodynamics is defined to include the indirect effects of holding delta smelt in the interior Delta longer than would occur under more natural flow conditions. We assumed that the mortality rate in the interior Delta is higher than that in Suisun Bay, where most juvenile rearing occurs. Thus, the effect does not imply changes in mortality rates but differing durations of exposure to different mortality rates. The higher mortality rate was presumed to occur through longer exposure of delta smelt to undefined mortalities that occur in the central Delta. These sources of mortality could include predation by species common in the Delta such as largemouth bass and silversides, differences in water quality, or differences in food production and availability in different areas. The Team recognizes that this assumption is based on sparse data but the view is consistent with the existing view of delta smelt ecology (Moyle et al. 1992, U.S. Fish and Wildlife Service 1995a,b). The environmental cues delta smelt use to migrate to Suisun Bay (assuming active rather than passive transport) are unknown but the simplest assumption is that they can detect or use the net direction of water movement in combination with tidal flux to choose a migration path. If this process is correct, delta smelt could be transported, either actively or passively, in the direction of the net flows described in the modeling runs that form the basis of the assessment. The effects of hydrodynamics were assessed by explicitly considering the following geographic locations identified in modeling runs: 1) cross Delta flow; 2) Qwest; 3) Old River @ Bacon Island; 4) Sacramento River at Rio Vista; 5) San Joaquin River at Antioch.

Predation: Predation includes all predation other than that occuring in Clifton Court Forebay and in front of screens.

Handling: Handling losses are included in entrainment. Handling is associated with a very high level of mortality given the delicate nature of delta smelt.

Food supply: Recent studies of delta smelt feeding indicate that the availability of appropriate food types may be very important at certain points in the delta smelt life cycle and for overall survival (Nobriga 1998, Lott and Nobriga, in prep.). Food supply summarizes the best guess of the team as to the effects certain actions will have on availability of food to the population.

Shallow-water habitat: Assessments of shallow-water habitat are based on possible effects on spawning habitat and food supply. The Team assumes that the majority of shallow-water habitat rehabilitation will involve perennial tidal marsh located in the interior Delta. Nothing definitive is known about the need of delta smelt for perennial tidal marsh habitat. This type of habitat is known to be used for spawning but it is unclear if spawning habitat is limited under present conditions. There is no compelling evidence that this habitat is used as rearing habitat. Past assessments of delta smelt ecology suggest that shoal habitat is important in Suisun Bay (Moyle et al. 1992, U.S. Fish and Wildlife Service 1995a,b) indicating that rehabilitation of shoal habitat in the western Delta might provide some benefit. However, ongoing studies of delta smelt habitat use suggest that larval and juvenile delta smelt are not selecting the shallow (<3m) edges of the channels compared to the deeper mid-channel areas (Sweetnam, unpublished data). Given the uncertainty in location and types of habitats to be rehabilitated and the benefit of shallow-water habitat as rearing habitat, shallow-water rearing habitat was not considered in the assessment.

Water quality (temperature): The Team believed that none of the alternatives would have a major effect on in-Delta water temperatures. This row was scored 0 through all matrices; therefore it was omitted from the matrices.

Salinity/X2 (originally called Water quality (salinity)): For delta smelt, the original "Water quality (salinity)" row was changed to Salinity/X2. We believe this better defines the variable of interest for delta smelt.

Agricultural diversions: The Team assumed an aggressive program of screening and consolidation of in-Delta agricultural diversions. Screen design was assumed to have some benefit for various life stages of delta smelt

Sources of uncertainty

The Team identified many sources of uncertainty. New data addressing. The major areas are identified below. Additional text is provided in the narrative for each of the alternatives.

We do not know the absolute size of the delta smelt population. All effects are based on sampling data from the various existing monitoring programs, including: 1) mid-channel vs. shallows larval sampling; 2) the 20-mm estuary-wide juvenile survey (includes flooded tracts); 3) Real-time Monitoring Program; 4) midwater trawling; 5) kodiak trawling; and 6) fish salvage at the state and federal pumping plants. The Team considered all of these relevant programs to minimize any bias that might result from considering data from any single sampling method or sampling design.

Screening criteria for both large project screens and smaller agricultural screens are unknown. Benefits for delta smelt are assumed; however, recent behavioral studies suggest that it may be very difficult to design screens that actually benefit delta smelt to a significant degree (Swanson et al 1998). It was also assumed there was some benefit to all life stages, which may not be the case depending on final screen design.

The benefits of shallow-water habitat rehabilitation to delta smelt are unknown. Such habitat is used for spawning and may contribute to overall productivity of the system. It is not known if spawning habitat is a limiting factor for the population. Shallow-water habitat is not believed to be an important rearing habitat for delta smelt. The Team assumes that the majority of shallow-water habitat rehabilitation will involve perennial tidal marsh located in the interior Delta. Nothing definitive is known about the need of delta smelt for perennial tidal marsh habitat. There is no compelling evidence that this habitat is used as rearing habitat. Past assessments of delta smelt ecology suggest that shoal habitat is important in Suisun Bay (Moyle et al. 1992, U.S. Fish and Wildlife Service 1995a,b) indicating that rehabilitation of shoal habitat in the western Delta might provide some benefit. However, ongoing studies of delta smelt habitat use suggest that larval and juvenile delta smelt are not selecting the shallow (<3m) edges of the channels compared to the deeper mid-channel areas (Sweetnam, unpublished data). Given the uncertainty in location and types of habitats to be rehabilitated and the benefit of shallow-water habitat as rearing habitat, shallow-water rearing habitat was not considered in the assessment.

We have little understanding of in-Delta predation dynamics on delta smelt.

As indicated at several points above, we have relatively little understanding of limiting factors for the delta smelt population. Recent studies suggest that availability of specific food types at specific times may be very important (Nobriga 1998, Lott and Nobriga, in prep.).

Existing Conditions

Entrainment: Entrainment values are based on historical salvage of delta smelt at the water project diversions in the South Delta. The strongest negative effects occur in the late spring/early summer when young-of-the-year delta smelt become large enough to be counted as salvage at the facilites in May, June and July. Entrainment of larval and early juvenile delta smelt < 21 mm are not counted as take at these facilities, therefore salvage data does not represent larval losses to entrainment and the peak effect might be prior to the salvage peaks observed in May or June. Screening efficiencies and pre-screening losses (e.g., predation) for delta smelt are not known so actual losses of delta smelt cannot be calculated. We assume that significant predation occurs on delta smelt entrained into Clifton Court Forebay, however it may be comparable to other species of the same size and shape (and swimming ability). The Team acknowledges that there are differences among life stages in the probability of survival to reproduction, with earlier life stages having lower probabilities but without carefully designed and implemented studies of life-stage specific mortality rates, the magnitude and importance of the differences is uncertain. The Team did qualitatively consider the relative importance of larval, juvenile, and adult effects.

Delta smelt usually do not survive the handling process, therefore the larger the potential for handling smelt, the larger the potential negative effect. Handling of delta smelt was also assumed to be proportional to entrainment effects. More delta smelt are entrained in dry years therefore the potential for handling mortality increases. Survival may also be influenced by water temperature, which would be higher in dry years.

Secondary effects of moving delta smelt out of optimal delta smelt rearing areas is covered under hydrodynamics.

The negative effects of entrainment are strongest in dry years when a larger proportion of the population is located in the delta for a longer period of time. In wet years, the population is more widely dispersed and distributed from the Delta to Suisun Bay. A second period of entrainment occurs in the late winter and early spring when pre-spawning adults move to freshwater to spawn.

Hydrodynamics: The effects of project related hydrodynamics on delta smelt occur mainly in the spring and summer months when pre-spawning adults move upstream to spawn and young-of-the-year delta smelt are present in freshwater before migrating to brackish water in the summer. The rest of the year, delta smelt are usually associated with the low salinity areas of the estuary west of the Delta, primarily Suisun and Grizzly bays. The negative effects of hydrodynamics in dry years are stronger and longer in duration than in wet years (DWR 1994, Biological assessment of ...).

Cross-Delta Flow: There may actually be some Cross-Delta flow in wet years but little effect is expected because of general high outflow conditions in wet years. In dry years, Cross-Delta flow will be [positive] larger and tend to move delta smelt spawned above the Delta Cross-Channel toward the central and southern Delta channels. The modeling studies used in this assessment use the variable Cross Delta Flow which combines flows in Georgiana Slough, the Delta Cross

Channel, and Snodgrass Slough/Alternative 2 discharge. The modeling runs provided assume that the Delta Cross Channel Gates are open from 1 July to 1 November. Particle tracking results verify that Cross-Delta flow occurs through Georgiana Slough when the Cross Channel Gates are closed.

Qwest: Qwest is generally positive over the period of record so it was assumed that Qwest would be positive in wet years and there would be little effect on delta smelt. In dry years, Qwest is negative in most months and only slightly positive in the remaining months. As described earlier, the retention of delta smelt in the Delta was felt to be a significant negative effect on the population, particularly for larvae and juveniles in the spring months.

Old River @ Bacon Island: Based on the 1975-1991 period of record analyzed, flow in Old River was negative during all months. Spawning in wet years is diffuse and significant spawning can occur in the central and southern Delta. A slight negative effect was assigned in the winter because adults could be induced to spawn farther south than they would otherwise and larvae and juveniles spawned in the area would be held in the area of the pumps longer. During dry years negative flow in the area is assumed to be high. This negative flow is assumed to retain larvae and juveniles in the southern Delta and this is presumed to have a negative impact on survival. Particle-tracking model results indicate that 62% of the particles injected into Old River are exported from the pumping facilities within 20 days. This suggests that weakly swimming larvae are likely moved toward the pumps for some period of time, even if they are not directly entrained.

Sac River @ Rio Vista: Sacramento River flow is strongly positive during wet years with no effect expected on delta smelt. Sacramento River flow will be lower in dry years but this is not felt to be a major effect on the delta smelt population. Most of the negative effects are already implicitly included in the Qwest effect indicated above. In dry years, delta smelt accumulate in the Sacramento River and will be subject to the Qwest effect. The delta smelt remaining in the more upstream portion of the Sacramento River were also felt to be negatively affected, but not to the degree of the rest of the population. Current regulatory requirements in the 1995 Water Quality Control Plan limits the movement of X2 into the Sacramento River channel. The Team believed a relatively small proportion of the population used the portion of the Sacramento River above Hood for spawning in dry years.

San Joaquin River @ Antioch: San Joaquin River flows likely stay positive during all months during wet years with little effect expected on delta smelt. In dry years, flow in the San Joaquin River is dramatically reduced. Significant reverse flows occur in some months. Moyle et al. (1992) hypothesized that this is a negative effect on the delta smelt population. The negative values for this parameter indicate longer residence time in an area where survival was believed to be relatively poor. Fish in this area might also be vulnerable to moving into areas subject to the other effects described above (e.g. Old River flows).

Predation: There were two main types of predation that were considered for delta smelt: larval predation by inland silversides, and predation at structures other than screens by striped bass, largemouth bass, etc. Predation effects are diminished in wet years when the smelt population was widespread with a larger proportion out of the Delta. The potential for inland silverside predation appears to be greatest in drier years when the majority of the population spawns above the Confluence. Predation on adults was considered to be relatively low with the effect increasing in months when larvae and juveniles are present.

Food Supply: Recent studies suggest that *Eurytemora affinis* is a preferred food item of delta smelt Nobriga 1998, Lott and Nobriga in prep.). Redutions in *Eurytemora* abundance through the introduction of exotic species such as clams (*Potamocorbula*) and copepods (*Psuedodiaptomus, Sinocalanus*, etc.) has led to the potential for food limitation for delta smelt. Wet years provide higher levels of food production in the estuary and decrease the effects of the clam on the ecosystem.

The negative effect of exporting a proportion of the food production with withdrawal of water from the estuary was also considered. This effect was not considered important in wet years. In dry years a negative effect was assigned. The negative effect appears earlier than direct effects of entrainment because the Team felt that earlier export of primary production, nutrients, and zooplankton might have some effect on productivity later in the season, even though fish were not present.

Shallow/Nearshore Habitat: Shallow or nearshore habitat is important to delta smelt as spawning habitat. It is not believed to be as important to delta smelt as rearing habitat. It was difficult to assign a value to this for two reasons. First, while it is clear that such habitat has declined it is unkown whether spawning habitat is a limiting factor on the population. Effects were assigned during the spawning season from December through May; however, uncertainty with the existence and magnitude of any effect is very high. Even thought the location and amount of available spawning habitat varies between wet and dry years the team did not feel that the magnitude of the effect varied enough to warrant a change in effect especially given the level of uncertainty involved. Second, the Team also believes that shallow-water habitat may have some value as a source of nutrients and production to the channels.

Water Quality (Temperature): Delta water temperatures are not controlled by water project operations. As water temperatures increase in the delta, delta smelt are thought to move to cooler portions of the estuary, therefore the delta smelt team decided that there was "no effect" of temperature on delta smelt for either water year type.

Water Quality (Salinity/ X2 Position): The delta smelt team decided that the effects of salinity on delta smelt are best described by the relationship between delta smelt abundance and X2 position. Delta smelt are most abundant when X2 is located in Suisun Bay in the spring. Although the relationship is somewhat weak, it does explain a statistically significant proportion of the variance (about 20%). However, much of the variability in the delta smelt population is unaccounted for by X2 alone. Maintenance of X2 position is mainly dependent on freshwater inflow to the estuary. In wet years, the salinity gradient has little effect on delta smelt except in the summer months when outflow declines and the gradient moves upstream into the Delta. In dry years, the effects of salinity may be much longer and last from February through November. The months of February through April were given positive effects in order to reflect export limitations and X2 flow requirements under the 1995 Water Quality Control Plan.

Agricultural Diversions: There are over 1800 agricultural diversions in the delta, which at times in the summer may export a similar magnitude of water as the export facilities in the south delta. Additional agricultural diversions in Suisun Marsh have the ability to entrain delta smelt when the population is located farther downstream in Suisun Bay. Not only do these exports have the potential to entrain larval and juvenile fishes, plankton and nutrients are also diverted. There may be agricultural diversion effects on delta smelt year round in different areas of the estuary, however the majority of impact would be at high levels of diversion in the spring and summer.

No Action Conditions

Entrainment: Based on modeling runs the majority of the increased diversions resulting from the 2020 level of demand would occur in December-March and July-August. The largest increases in exports (resulting in higher levels of entrainment) occur in February and March in wet years, and December-March in dry years. During this period, pre-spawning adults might be entrained at higher rates. The July increase in wet years was given a greater effect because young-of-year delta smelt are more likely to be in the area at that time compared to August.

Hydrodynamics: Changes in hydrology based on the increased level of demand are similar to existing conditions with increases in negative effects observed throughout the winter and spring. The magnitude of the effect might be greater in wet years since additional water would be available to be exported in the spring. Negative effects were lessened in April of both year types for export constraints already in place. The reduction did not carry through May because protections are curtailed while large numbers of young smelt are still present. San Joaquin River at Antioch appeared slightly worse in December and January, which may have an effect on adult delta smelt staging to move into the Delta.

Predation: No change from existing conditions for wet years with no additional effect. In dry years there is the potential for increased effects in the winter when additional water is exported; however, no changes in scores were made.

Handling: No change from existing conditions for wet years with no additional effect. In dry years there is the potential for increased effects in the winter when additional water is exported; however, no changes in scores were made.

Food Supply: With increased exports in the winter, higher levels of primary production and zooplankton are also exported. The team decided that this additional effect would be observed in December and January.

Shallow/Nearshore Habitat: The increased level of demand in the No Action Alternative would not change the amount or effect of shallow/nearshore habitat.

Water Quality (Temperature): No change from existing conditions.

Salinity/ X2 Position: According to the modeling runs available, there is little discernible difference in X2 position between the existing and no action conditions. The numbers in the matrix reflect these numbers. (For the consideration of the group our original comments were: With increased exports in the winter and early spring, there might be additional effects on habitat conditions in the spring. In wet years, these effects may be observed in January and February if rainfall occurs later in the spring. In dry years the effect may be observed from December through March. Our original comments were based on extrapolations from total Delta outflow.)

Agricultural Diversions: Unless there is same change in demand, no change in existing conditions is anticipated.

Common Programs

Entrainment: The Common programs do not address this issue.

Hydrodynamics: The Common programs do not address this issue.

Predation: The Common programs do not address this issue.

Handling: The Common programs do not address this issue.

Food Supply: Restoration programs and increases in Shallow/nearshore habitat may lead to increases in primary production, which may be a benefit year round.

Shallow/Nearshore Habitat: Additional shallow/nearshore habitat may benefit delta smelt in terms of spawning habitat. Shallow water areas as nursery habitat do not appear to be that important to delta smelt. This benefit is uncertain because there is no evidence that shallow/nearshore habitat is a limiting factor on the population.

Water Quality (Temperature): Common programs may affect the temperature of water coming into the Delta but no in-Delta change is anticipated.

Salinity/ X2 Position: The Common programs do not address this issue.

Agricultural Diversions: There is a net benefit of screening for delta smelt, which may be observed throughout the entire year. The largest magnitude of a positive benefit of screening would be observed in months when delta smelt are in close proximity to agricultural diversions and demand is high. This assumes that screening criteria and diversion consolidation can be designed to minimize effects on all life stages of delta smelt. Benefits will have to be adjusted if only certain life stages are benefited. This benefit includes screening and consolidation in Suisun Marsh.

Alternative 1

Alternative 1 was assumed to be the result of the benefits of the common programs above the existing conditions added to the No Action Alternative (expressed as Alt 1 = (Common Programs - Existing Conditions) + NA). See the text for the No Action alternative for explanations of factors.

Entrainment:

Hydrodynamics:

Predation:

Handling:

Food Supply:

Shallow/Nearshore Habitat:

Water Quality (Temperature):

Water Quality (Salinity/ X2 Position):

Agricultural Diversions:

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Alternative 2

Entrainment: Increased exports from the southern Delta in December through March in all years were assigned a large negative effect because of the size of the increase (about 3,000 cfs). A similar large increase occurred in July and August.

Less effect was assigned to direct entrainment at the times of the year when delta smelt would be large enough for effective screening, if screens with the correct criteria can be designed. Additional negative effects were assigned to handling because screened fish will have to pass through a bypass system. Clifton Court Forebay predation effects are now defined as taking place in front of the screens rather than in the Forebay proper. The greater effect in dry years results from a larger proportion of the population experiencing the effects.

Hydrodynamics: In wet years, modeling results indicate improvements in Qwest; however, Cross-Delta flows and Flows at Old River @ Bacon Island get worse. These negative effects outweigh the improvement in Qwest. In dry years, the negative effects are magnified, especially for Cross-Delta flow and Old River at Bacon Island. Reductions in flow of the Sacramento River were also assigned a negative value. Qwest remained favorable, except for June, July and August, when slight negative effects were assigned. Conditions in the San Joaquin River at Antioch remained favorable all year. The large negative effect of Alternative 2 is linked not only to hydrodynamic changes but to interactions with the physical changes as well. The Team believes that with this alternative any net production of delta smelt to the east of the "new" canal would be completely lost. It also seemed possible that young-of-year produced to the west of the new canal could be at risk if tidal action periodically moves young-of year in and out of the areas influenced by the new canal. It seems likely that hydrodynamic effects of east-west (more or less) tides on the water moving north-south (more or less) in the canal will be complex and difficult or impossible to model with existing tools.

Predation: No change from Alternative 1.

Food Supply: No change from Alternative 1.

Shallow/Nearshore Habitat: The possible benefits of shallow/nearshore habitat were reduced because strong Cross-Delta flows would reduce the value of such habitat within the influence of the diverted water.

Salinity/ X2 Position: No change from Alternative 1.

Agricultural Diversions: No change from Alternative 1.

Alternative 3

Entrainment: The isolated facility reduces entrainment effects substantially and a large positive benefit (compared to existing conditions) is assigned. Reduction in predation is assigned a similar benefit. There is still some pumping from the South Delta and some negative effect is still assigned to the fish that would go through the bypass facility.

Hydrodynamics: Alternative three improves Cross-Delta and Old River flows substantially resulting in substantial improvement for delta smelt. Positive benefits are assigned to increased San Joaquin River flows in this alternative because there is no longer any complicating interactions with Cross-Delta and Old River flows, which stay positive in all months.

In dry years positive benefit was assigned to Old River at Bacon Island because negative flows were reduced and in February-June were near zero.

Predation: Predation in the Delta declines because hydrodynamics are now favorable and fish are no longer held in the Delta for an extended period of time.

Food Supply: No major change from Alternative 1.

Shallow/Nearshore Habitat: No change from Alternative 1.

Salinity/ X2 Position:

Modeling results indicate a decrease in X2 position of roughly 2 kilometers in July and 6 kilometers in August (also 4 kilometers in September). This was given a positive benefit though it seems inconceivable to the Team that this is not a mistake. Why would Alternative 3 be operated in this way?

Agricultural Diversions: No change from Alternative 1.

Primary Issues

1. **Which species, populations, and life stages are most sensitive to diversion effects under no action and alternatives 1, 2, and 3? When and where are they most affected?**

No Action: Larvae and young juveniles are the most sensitive life stages. These life stages are present in the spring and early summer. The major effects occur in the central and south Delta where altered hydrodynamics and entrainment are important. As delta smelt become adults, they migrate downstream to brackish water areas in the fall and winter and are considered less vulnerable to diversion effects. Pre-spawning adults migrating back into freshwater to spawn in the late winter and early spring become vulnerable to entrainment effects once again.

Alternative 1: The same as No Action.

Alternative 2: Larvae and young juveniles are still the most sensitive stages and are still vulnerable at the same times. The major changes in hydrodynamics anticipated with Alternative 2 are believed to be a negative factor for all life stages of delta smelt, but especially these sensitive stages. These negative effects are expected to be most severe in the eastern Delta.

Alternative 3: Alternative 3 was given high benefit because of its positive effects on returning Delta hydrodynamics to a more "natural" condition, meaning the rivers and most channels maintain positive outflows at most times and places. Positive benefits for delta smelt may be high compared to other species because it is the only species to complete its entire life cycle in the estuary.

2. **Can diversion effects in the South Delta be offset by habitat improvements and other common program actions?**

No, common program actions have very uncertain effects for delta smelt but it seems unlikely that the positive benefits will outweigh the entrainment and hydrodynamic effects.

3. **To what extent can alternatives 1, 2, and 3 offset diversions effects as presently configured?**

Alternative 1: Little effect.

Alternative 2: Makes things much worse.

Alternative 3: Makes things better.

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4. **To what extent can diversion effects be offset by modifications to the alternatives or by operational changes?**

   (Not to be answered yet)

5. **What is the risk and chances of success of species recovery for each alternative?**

   For the delta smelt team recovery is defined in "The Recovery Plan for the Sacramento/San Joaquin Delta Native Fishes" (Attachment 1). Alternative 1 is not a major change and probably has little influence on probability of recovery. Alternative 2 seems likely to negatively affect probability of recovery. Alternative 3 seems likely to improve the probability of recovery. All of these assessments are subject to the uncertainties already identified above.

6. **What increment of protection or improvement for delta smelt will be provided by other programs such as the CVPIA, biological opinions?**

   The protections set forth for delta smelt under the Biological Opinion (USFWS 1995a) on the operation of the State and Federal water project diversions are similar to conditions set forth in the 1994 Water Accord and therefore are considered part of the baseline conditions known as "existing conditions" in the model runs provided.

7. **What degree of benefit and impact will the common programs provide?**

   We estimated that improvement would occur with the common programs. Much of the benefit predicted is due to the creation of additional shallow water habitat of several different types. The effect on delta smelt is uncertain. Much of this uncertainty stems from the scarcity of evidence of the effects of increasing such habitat. Delta smelt use such habitat for spawning but it seems to be of no special importance as rearing habitat. There is no evidence that spawning habitat is a limiting factor for the delta smelt population. While the habitat will also be favorable for predators, the increased spawning habitat and possible increases in Delta primary productivity and food supply were believed to be possible benefits and were assigned benefits even though this is an area of high uncertainty. Screening Delta diversions and improved Delta water quality are also expected to be beneficial.

8. What are the direct and indirect effects on delta smelt populations resulting from each Alternative and what is the expected response of the populations to these effects?

   The improvement in conditions for Alternatives 1 and 2 are purely a result of the benefits assigned to the common programs. Neither of these alternatives improves in-Delta hydrodynamics to a significant degree, and the team believes that Alternative 2 will result in hydrodynamic conditions that are significantly worse than any other alternative. Alternative 3 performs best for delta smelt because the hydrodynamic changes associated with this alternative appear likely to have positive effects on the delta smelt population in addition to the positive effects of the common programs.

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A summary of our assessments suggest that Alternatives 1 and 2 will aid the delta smelt population somewhat, through improvements related to the common programs, and that Alternative 3 represents a significant improvement. However, it is unclear if the population will actually benefit to the degree anticipated in this document. Recent studies suggest that the success of the delta smelt population might be linked to timing and abundance of particular food organisms. Further, the ecology of these food organisms may be linked more to the effects of introduced predators and competitors than to the issues addressed in the alternatives. If this is actually the case, then the anticipated beneficial effects of the alternatives for delta smelt might not actually be achieved.

9. **What Sacramento River flow is required below a Hood diversion to protect delta smelt?**

10. **What survival rate can be expected for delta smelt passing through Sacramento River screen and pumps in Alternative 2?**

11. **Should there be a screen on the Sacramento River intake of Alternative 2?**

    Yes.

12. **What are the logical stages for a preferred alternative?**

13. **What is the range of biological criteria that should be considered in the operations of the three alternatives?**

References

(including Attachment 1)

Moyle, P.B., B. Herbold, D.E. Stevens, and L.W. Miller. 1992. Life history and status of delta smelt in the Sacramento-San Joaquin Estuary, California. Transactions of the American Fisheries Society.121:67-77.

Swanson, C. P.S. Young and J.J. Cech. 1998. Swimming performance of delta smelt: maximum performance, and behavioral and kinematic limitations on swimming at submaximal velocities. Journal of Experimental Biology: 201, 333-345.

Sweetnam, D.S. and D.E. Stevens. 1993. Report to the Fish and Game Commission: a status review of the delta smelt, (*Hypomesus transpacificus*) in California. California Department of Fish and Game. Candidate Status Report 93-DS.

U.S. Fish and Wildlife Service. 1995a. Formal consultation and conference on effects of long-term operation of the Central Valley Project and the State Water Project on the threatened delta smelt, delta smelt critical habitat, and proposed threatened Sacramento splittail, March 6, 1995. U.S. Fish and Wildlife Service, Portland Oregon. 52pp.

U.S. Fish and Wildlife Service. 1995b. Sacramento-San Joaquin Delta Native Fishes Recovery Plan. U.S. Fish and Wildlife service, Portland, Oregon. 195pp.

Attachment 1

The following is the Recovery section of the Recovery Plan for the Sacramento/San Joaquin Delta Native Fishes for delta smelt (USFWS 1995b), pages 29-34 and 37-38:

RECOVERY

Recovery Objective

The objective of this part of the Delta Native Fishes Recovery Plan is to remove delta smelt from the Federal list of threatened species through restoration of its abundance and distribution. Recovery of delta smelt should not be at the expense of other native fishes. The basic strategy for recovery is to manage the estuary in such a way that it is a better habitat for native fish in general and delta smelt in particular. Improved habitat will allow delta smelt to be widely distributed throughout the Delta and Suisun Bay, recognizing that areas of abundance change with season. Recovery of delta smelt will consist of two phases, restoration and delisting. Separate restoration and delisting periods were identified because it is possible that restoration criteria can be met fairly quickly in the absence of consecutive extreme outflow years (I. e., extremely wet or dry years). However, without the population being tested by extreme outflows there is no assurance of long-term survival for the species. Thus, restoration is defined as a return of the population to pre-decline levels, but delisting is not recommended until the population has been tested by extreme outflows. Delta smelt will be considered restored when its population dynamics and distribution pattern within the estuary are similar to those that existed in the 1967-1981 period. This period was chosen because it includes the earliest continuous data on delta smelt abundances and was a period in which populations stayed reasonably high in most years (see below for a more detailed justification). The species will be considered recovered and qualify for delisting when it goes through a five-year period that includes two sequential years of extreme outflows, one of which must be dry or critically dry. Delta smelt will be considered for delisting when the species meets recovery criteria under stressor conditions comparable to those that led to listing and mechanisms are in place that insure the species' continued existence.

Recovery Criteria

Restoration of delta smelt should be assessed when the species satisfies distributional and abundance criteria. Distributional criteria include: (1) catches of delta smelt in all zones 2 of 5 consecutive years, (2) in at least two zones in 1 of the remaining 3 years, and, (3) in at least one zone for the remaining 2 years. Abundance criteria are: delta smelt numbers or total catch must equal or exceed 239 for 2 out of 5 years and not fall below 84 for more than two years in a row. Distributional and abundance criteria can be met in different years. If abundance and distributional criteria are met for a five-year period the species will be considered restored. Delta smelt will meet the remaining recovery criteria and be considered for delisting when abundance and distributional criteria are met for a five-year period that includes two successive extreme outflow years, with one year dry or critical. Delisting is contingent on the placement of legal mechanisms and interagency agreements to manage the CVP, SWP, and other water users to meet these criteria. Both criteria depend on data collected by DFG during the FMWT, during September and October.

Justification for using FMWT numbers: The FMWT covers the entire range of delta smelt distribution and provides one of the two best measures of delta smelt abundance (Sweetnam and Stevens 1993). The summer tow-net survey samples juveniles of this annual species and provides another good measure of abundance. The FMWT provides a better measure of abundance because it samples pre-spawning adult delta smelt. An index based on pre-spawning adults, rather than on juveniles, which are vulnerable to high mortality, provides a better estimate of delta smelt stock and recruitment. The FMWT may not be as efficient at sampling delta smelt compared with the Kodiak trawl, which is pulled by two boats and tends to sample the upper water column, but it has been continuously done for almost 30 years (since 1967) and so has a solid base of historical data with known sampling error.

September and October numbers of adults were chosen, because these are the months that were sampled most consistently in all years. In addition, when delta smelt begin moving upstream to spawn in November and December, they occur less frequently in the FMWT. Weather conditions are also more stable in September and October. The more frequent storms of November and December produce conditions that result in more variability in fish-capture numbers. There is a high correlation between September and October numbers and total numbers ($r= 0.93$).

Number of delta smelt rather than abundance index was used for recovery criteria. The abundance index was initially developed for striped bass. Numbers were chosen because delta smelt occupy the upper water column. Multiplying delta smelt captured by volume of water in the portion of the estuary sampled probably doesn't give a good representation of the number of fish present. Using numbers for delta smelt simplifies the assumptions of the criteria and there is a close correspondence between numbers and the abundance index for delta smelt ($r=0.89$).

Justification for using 1967-1981 for the standard: Graphs from different surveys were used to establish pre-decline and post-decline periods for delta smelt (Moyle *et al.* 1992). The surveys included were: (1) FMWT, (2) summer tow-net, (3) Suisun Marsh fish survey, and, (4) the bay survey (Appendix A). Each of the surveys showed slightly different patterns of decline. The most noticeable trend is that delta smelt decline began earlier in the south and east Delta than in the rest of the estuary (Sweetnam and Stevens 1993). The pre-decline period identified by Moyle *et al.* (1992) is 1967 through and including 1981; the post-decline period is 1982-92. Using 1982 as the beginning of the decline period is justified because 1982 and 1983 were very wet years and declines in delta smelt abundance correspond to extremes in outflow: very wet and very dry years result in low numbers (Moyle *et al.* 1992). The mechanisms for this are that delta smelt larvae are washed downstream of favorable nursery grounds in wet years; dry years decrease spawning habitat and move adults and juveniles upstream into less productive deep river channels where they are more at risk to entrainment in water projects.

Other alternatives were proposed for the decline period. One possibility was to use 1981 as the beginning of the decline period because it was a dry year followed by the wet year 1982. The occurrence of a dry year followed by a wet year produces a double stress on delta smelt and this may have been the true beginning of the decline. An argument can also be made for using 1983 as the beginning of the decline: this is the year that delta smelt declined in the FMWT and so is consistent with other recovery criteria (which is based on the FMWT). There is a noticeable change in geographic distribution of delta smelt in 1982 and 1983, which corresponds to the periods used in the Biological Opinion and the decline in FMWT numbers, respectively. The decline in delta smelt numbers actually occurred over a multi-year period from 1981-1983; the midpoint of this period, 1982, was used as the beginning of the decline.

Justification for including distributional recovery criteria: Geographical distribution and numbers of fish were used to measure recovery because recovery of delta smelt should include a restoration of the species to portions of their former range. Before 1982, delta smelt were captured at an average of 19 FMWT stations; after 1981 they were captured at an average of 10 stations. From 1986-1992, the delta smelt population was concentrated in the lower Sacramento River between Collinsville and Rio Vista (Sweetnam and Stevens 1993). Historically, when delta smelt were more abundant, the population was spread from Suisun Bay and Montezuma Slough through the Delta. The shallow, productive waters of Suisun Bay and Suisun Marsh are important habitat for delta smelt. Large percentages of delta smelt catches are in Suisun Bay when outflows are sufficient to maintain the mixing zone and salinities of 2-3 parts per thousand in that area. When concentrated in deep river channels due to intrusion of high salinities in Suisun Bay, delta smelt are more vulnerable to entrainment in water project facilities, predation and other risks.

FMWT stations chosen to measure recovery: Stations chosen for recovery criteria were sampled in every year (that the FMWT was conducted) and had a record of delta smelt catches. Occasionally, this was modified to include stations sampled in all years but one (stations 509, 511, 602). The total number of stations is 35 and there is a strong correlation between delta smelt at **these stations and** total numbers of delta smelt (r = 0.94).

Zone A (North Central Delta)
11 stations
802 804 806 808 810 812 814 903 904 906 908

Zone B1 (Sacramento River)
5 stations
701 703 705 707 709

Zone B2 (Montezuma Slough)
4 stations
602 604 606 608

Zone C (Suisun Bay)
15 stations
410 412 414 416 418 501 503 505 507 509 511 513 515 517 519

Distributional criteria: Distributional criteria were developed on the basis of number of stations in each zone where delta smelt were captured during the predecline period (Tables 2.2, 2.3, Figures 2.7 and 2.8). Each zone has the following criteria: (1) in Zone A, delta smelt must be captured in 2 of 11 sites; (2) in Zone B (includes B1 and B2), delta smelt must be captured in 5 of 9 sites; and (3) in Zone C, delta smelt must be captured in 6 of 15 sites. Criteria for all zones need to be met in all years. Criteria for recovery are as follows: (1) site criteria must be met in all zones 2 of 5 consecutive years, (2) in at least two zones in 1 of the remaining 3 years, and, (3) in at least one zone for the remaining 2 years. A failure in all zones in any year will result in the start of a new 5-year evaluation period for the distributional criteria. Failure to meet these criteria in consecutive years should be avoided because such conditions will place the species in danger of extinction. These distributional criteria will be met in concert with the abundance criteria.

Abundance criteria: Abundance of delta smelt constituting recovery is based on pre-decline delta smelt numbers from the FMWT (Table 2.3). Two numbers were identified that had to be met during the five-year recovery period: (1) a low number below which abundance can not fall for more than two years in a row and, (2) a high number to be reached or exceeded in two out of five years. A low number was chosen to protect delta smelt from the risk of extinction during prolonged droughts or extremes of outflow. The lowest two-year running average of abundance in the pre-decline years was used for the low number. A running average was used because of the great degree of variability in delta smelt abundance. The high number is the median of delta smelt abundance in pre-decline years, in other words, abundance of delta smelt half of the time in the pre-decline period. To meet recovery criteria, delta smelt abundance must meet or exceed 239 in two out of five years and the two-year running average must never fall below 84. If any of these conditions are not met, the five-year recovery period will start again.

Length of restoration and recovery period: Delta smelt generation time and frequency of occurrence of very dry and very wet years were used to determine appropriate length of the restoration period. Because delta smelt live only a year, a five-year recovery period would include five generations of delta smelt; five generations is comparable to the period used in recovery plans for other fishes. A five-year restoration period has a reasonable probability of including years with extreme outflow. The 40:30:30 (Footnote: Year-type categories adopted by the SWRCB in the 1991 Salinity Control Plan.) Sacramento River Indices (SRI) from 1906-1992 was used for this analysis. The goal was to identify a period that had a high probability of including two extreme outflow years, preferably back-to-back. This method was chosen because when two extreme years occur together, delta smelt are at risk of extinction. Because extremes in outflow led to the listing of the delta smelt, the period identified for recovery differs from restoration and includes a stressor period. Delta smelt will be considered for delisting when abundance and distributional criteria have been met over a five-year period that includes two sequential years of extreme outflows. However, delisting may not take place until there is reasonable assurance that long term solutions to delta problems are in place. One of the extreme years must be dry or critically dry (SRI $\leq$6.0); the other can be wet SRI $\geq$11.2). Other indices can be used to identify dry, critically dry, and wet years, if appropriate. Dry conditions are included because delta smelt losses increase in dry and critical years due to high proportions of outflow diverted, which results in habitat loss and increased entrainment in water projects. Analysis of the historical hydrograph indicated that there is about a 24 percent chance that two extreme years (one being dry or critical) will occur in a five-year period. There is a 48 percent chance (based on the historical hydrograph) that the period of time required to delist delta smelt could be 10 years. According to existing records, the longest amount of time required to delist delta smelt is 38 years.

Table 2.2 Number of sites with delta smelt from FMWT September and October numbers for 35 stations. Numbers in brackets refer to station numbers. The FMWT did not sample in 1974 and 1979. See Figure 2.8 for how minimum number of sites was determined.

	Sites		
Year	Zone C Suisun Bay (410-519)	Zone B Montezuma Slough Sacramento River (602-709)	Zone A North Central Delta (802-908)
		Pre-decline	
1967	6	8	2
1968	9	6	8
1969	11	7	0
1970	12	8	7
1971	13	8	8
1972	12	8	9
1973	9	9	4
1975	12	5	5
1976	1	5	2
1977	0	5	5
1978	11	6	0
1980	10	8	3
1981	8	6	0
Minimum number of sites	6 of 15	5 of 9	2 of 11
Number of years minimum number of sites occurred	11 out of 13	13 of 13	10 of 13
		Post-decline	
1982	6	6	1
1983	5	4	0
1984	9	3	0
1985	2	3	0
1986	10	5	1
1987	2	4	1
1988	3	3	0
1989	6	5	3
1990	4	6	0
1991	4	6	3
1992	0	5	1
1993	12	6	4
1994*	**1**	**5**	**1**
1995*	**14**	7	**1**
1996*	**8**	**4**	**2**
1997*	**3**	**4**	**1**
Number of years minimum number of sites occurred	7 out of 16	9 of 16	4 of 16

Table 2.3 Numbers used for delta smelt abundance criteria. Numbers are from the September and October FMWT for 35 stations. The FMWT did not sample 1974 and 1979.

Year	Number	Two-year running average
	Pre-decline	
1967	139	
1968	251	195
1969	128	190
1970	589	359
1971	352	471
1972	551	452
1973	305	428
1975	**239**	272
1976	22	131
1977	146	**84**
1978	108	127
1980	312	210
1981	78	195
	Post-decline	
1982	37	58
1983	17	27
1984	51	34
1985	29	40
1986	70	50
1987	72	71
1988	43	58
1989	76	60
1990	81	79
1991	171	126
1992	26	98
1993	400	213
1994*	**19**	**210**
1995*	**255**	**137**
1996*	**28**	**146**
1997*	**62**	**44****

*** - Criteria updated to 1997**
**** - Two-Year Running Average below 84 criteria**

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Diversion Effects on Delta Smelt: Existing Conditions WET YEARS

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Total
Entrainment	0	0	-1	-1	-1	-1	-2	-3	-2	-2	-1	0	-14
Entrainment (export)	0	0	-1	-1	-1	-1	-2	-3	-2	-2	-1	0	
CCF predation	0	0	-1	-1	-1	-1	-2	-3	-2	-2	-1	0	
Handling	0	0	0	0	0	0	-1	-2	-1	-1	0	0	
Hydrodynamics	0	0	-1	-1	-1	-1	-1	-1	-1	-1	-1	0	-9
Cross -Delta Flow	0	0	0	0	0	0	0	0	0	0	0	0	
Qwest	0	0	0	0	0	0	0	0	0	0	0	0	
Old River @Bacon Island	0	0	-1	-1	-1	-1	-1	-1	-1	-1	-1	0	
Sac River @ Rio Vista	0	0	0	0	0	0	0	0	0	0	0	0	
SJ River @ Antioch	0	0	0	0	0	0	0	0	0	0	0	0	
Predation	0	0	-1	-1	-1	-1	-1	-1	-1	-1	-1	0	-9
Food supply	0	0	0	0	0	0	0	0	0	0	0	0	0
Shallow/ nearshore habitat	0	0	-1	-1	-1	-1	-1	-1	0	0	0	0	-6
Salinity/X2	0	0	0	0	0	0	0	0	0	-1	-1	-1	-3
Agricultural diversions	0	0	0	0	0	0	0	-1	-2	-2	-2	0	-7
Total	0	0	-7	-7	-7	-7	-11	-16	-12	-13	-9	-1	-48

Diversion Effects on Delta Smelt: Existing Conditions DRY YEARS

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Total
Entrainment	0	0	-1	-1	-1	-2	-2	-3	-3	-3	-2	0	-18
Entrainment (export)	0	0	-1	-1	-1	-2	-2	-3	-3	-3	-2	0	
CCF predation	0	0	-1	-1	-1	-2	-2	-3	-3	-3	-2	0	
Handling	0	0	-1	-1	-1	-2	-2	-3	-3	-3	-2	0	
Hydrodynamics	0	0	-1	-1	-1	-2	-2	-3	-3	-3	-2	0	-18
Cross -Delta Flow	0	0	-1	-1	-1	-2	-2	-3	-3	-3	-2	0	
Qwest	0	0	-1	-1	-1	-2	-2	-3	-3	-3	-2	0	
Old River @Bacon Island	0	0	-1	-1	-1	-2	-2	-3	-3	-3	-2	0	
Sac River @ Rio Vista	0	0	0	0	0	0	-1	-2	-2	-2	-1	0	
SJ River @ Antioch	0	0	-1	-1	-1	-2	-2	-3	-3	-3	-2	0	
Predation	0	0	-1	-1	-1	-1	-2	-2	-2	-2	-2	0	-14
Food supply	0	-1	-1	-1	-2	-3	-3	-3	-3	-3	-2	-1	-23
Shallow/ nearshore habitat	0	0	-1	-1	-1	-1	-1	-1	0	0	0	0	-6
Salinity/X2	-1	-1	0	0	1	1	1	-1	-1	-1	-1	-1	-4
Agricultural diversions	0	0	0	0	0	0	-2	-2	-3	-3	-2	0	-12
Total	-1	-2	-12	-12	-12	-22	-26	-38	-38	-38	-26	-2	-95

Diversion Effects on Delta Smelt: No Action Conditions WET YEARS

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Total
Entrainment	0	0	-1	-1	-2	-2	-2	-3	-2	-3	-2	0	-18
Entrainment (export)	0	0	-1	-1	-2	-1	-2	-3	-2	-2	-1	0	
CCF predation	0	0	-1	-1	-1	-1	-2	-3	-2	-2	-1	0	
Handling	0	0	0	0	-1	-1	-1	-2	-1	-2	-1	0	
Hydrodynamics	0	0	-1	-1	-2	-2	-1	-2	-2	-2	-2	0	-15
Cross -Delta Flow	0	0	0	0	0	0	0	0	0	0	0	0	
Qwest	0	0	0	-1	-1	-1	0	0	0	-1	-1	0	
Old River @Bacon Island	0	0	-1	-1	-1	-1	-1	-1	-1	-1	-1	0	
Sac River @ Rio Vista	0	0	0	0	0	0	0	0	0	0	0	0	
SJ River @ Antioch	0	0	0	0	0	0	0	0	0	0	0	0	
Predation	0	0	-1	-1	-1	-1	-1	-1	-1	-1	-1	0	-9
Food supply	0	0	0	0	0	0	0	0	0	0	0	0	0
Shallow/ nearshore habitat	0	0	-1	-1	-1	-1	-1	-1	0	0	0	0	-6
Salinity/X2	0	0	0	0	0	0	0	0	0	-1	-1	-1	-3
Agricultural diversions	0	0	0	0	0	0	0	-1	-2	-2	-2	0	-7
Total	0	0	-7	-8	-12	-11	-11	-17	-13	-17	-13	-1	-58

Diversion Effects on Delta Smelt: No Action Conditions DRY YEARS

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Total
Entrainment	0	0	-2	-2	-2	-3	-2	-3	-3	-3	-2	0	-22
Entrainment (export)	0	0	-2	-2	-2	-2	-2	-3	-3	-3	-2	0	
CCF predation	0	0	-1	-1	-1	-2	-2	-3	-3	-3	-2	0	
Handling	0	0	-1	-1	-1	-2	-2	-3	-3	-3	-2	0	
Hydrodynamics	0	0	-2	-2	-2	-3	-2	-3	-3	-3	-2	0	-22
Cross -Delta Flow	0	0	-1	-1	-1	-2	-2	-3	-3	-3	-2	0	
Qwest	0	0	-1	-1	-1	-2	-2	-3	-3	-3	-2	0	
Old River @Bacon Island	0	0	-1	-1	-1	-2	-2	-3	-3	-3	-2	0	
Sac River @ Rio Vista	0	0	0	0	0	0	-1	-2	-2	-2	-1	0	
SJ River @ Antioch	0	0	-2	-2	-1	-1	-1	-2	-2	-2	-1	0	
Predation	0	0	-1	-1	-1	-1	-2	-2	-2	-2	-2	0	-14
Food supply	0	-1	-2	-2	-2	-3	-3	-3	-3	-3	-2	-1	-25
Shallow/ nearshore habitat	0	0	-1	-1	-1	-1	-1	-1	0	0	0	0	-6
Salinity/X2	-1	-1	0	0	1	1	1	-1	-1	-1	-1	-1	-4
Agricultural diversions	0	0	0	0	0	0	-2	-2	-3	-3	-2	0	-12
Total	-1	-2	-17	-17	-15	-23	-25	-37	-37	-37	-25	-2	-105

Diversion Effects on Delta Smelt: Common Programs WET YEARS

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Total
Entrainment	0	0	-1	-1	-1	-1	-2	-3	-2	-2	-1	0	-14
Entrainment (export)	0	0	-1	-1	-1	-1	-2	-3	-2	-2	-1	0	
CCF predation	0	0	-1	-1	-1	-1	-2	-3	-2	-2	-1	0	
Handling	0	0	0	0	0	0	-1	-2	-1	-1	0	0	
Hydrodynamics	0	0	-1	-1	-1	-1	-1	-1	-1	-1	-1	0	-9
Cross -Delta Flow	0	0	0	0	0	0	0	0	0	0	0	0	
Qwest	0	0	0	0	0	0	0	0	0	0	0	0	
Old River @Bacon Island	0	0	-1	-1	-1	-1	-1	-1	-1	-1	-1	0	
Sac River @ Rio Vista	0	0	0	0	0	0	0	0	0	0	0	0	
SJ River @ Antioch	0	0	0	0	0	0	0	0	0	0	0	0	
Predation	0	0	-1	-1	-1	-1	-1	-1	-1	-1	-1	0	-9
Food supply	1	1	1	1	1	2	2	2	1	1	1	1	15
Shallow/ nearshore habitat	0	0	0	0	1	1	1	1	1	0	0	0	5
Salinity/X2	0	0	0	0	0	0	0	0	0	-1	-1	-1	-3
Agricultural diversions	1	1	1	1	1	1	1	2	2	2	2	1	16
Total	2	2	-4	-4	-3	-2	-6	-9	-6	-8	-4	1	1

Diversion Effects on Delta Smelt: Common Programs DRY YEARS

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Total
Entrainment	0	0	-1	-1	-1	-2	-2	-3	-3	-3	-2	0	-18
Entrainment (export)	0	0	-1	-1	-1	-2	-2	-3	-3	-3	-2	0	
CCF predation	0	0	-1	-1	-1	-2	-2	-3	-3	-3	-2	0	
Handling	0	0	-1	-1	-1	-2	-2	-3	-3	-3	-2	0	
Hydrodynamics	0	0	-1	-1	-1	-2	-2	-3	-3	-3	-2	0	-18
Cross -Delta Flow	0	0	-1	-1	-1	-2	-2	-3	-3	-3	-2	0	
Qwest	0	0	-1	-1	-1	-2	-2	-3	-3	-3	-2	0	
Old River @Bacon Island	0	0	-1	-1	-1	-2	-2	-3	-3	-3	-2	0	
Sac River @ Rio Vista	0	0	0	0	0	0	-1	-2	-2	-2	-1	0	
SJ River @ Antioch	0	0	-1	-1	-1	-2	-2	-3	-3	-3	-2	0	
Predation	0	0	-1	-1	-1	-1	-2	-2	-2	-2	-2	0	-14
Food supply	1	0	0	0	-1	-1	-1	-1	-1	-1	-1	0	-6
Shallow/ nearshore habitat	0	0	0	0	1	1	1	1	0	0	0	0	4
Salinity/X2	-1	-1	0	0	1	1	1	-1	-1	-1	-1	-1	-4
Agricultural diversions	1	1	1	1	1	1	1	2	2	2	2	1	16
Total	1	0	-9	-9	-8	-17	-19	-30	-31	-31	-21	0	-40

E-003590

Diversion Effects on Delta Smelt: Alternative 1 WET YEARS

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Total
Entrainment	0	0	-1	-1	-2	-2	-2	-3	-2	-3	-2	0	-18
Entrainment (export)	0	0	-1	-1	-2	-1	-2	-3	-2	-2	-1	0	
CCF predation	0	0	-1	-1	-1	-1	-2	-3	-2	-2	-1	0	
Handling	0	0	0	0	-1	-1	-1	-2	-1	-2	-1	0	
Hydrodynamics	0	0	-1	-1	-2	-2	-1	-2	-2	-2	-2	0	-15
Cross -Delta Flow	0	0	0	0	0	0	0	0	0	0	0	0	
Qwest	0	0	0	-1	-1	-1	0	0	0	-1	-1	0	
Old River @Bacon Island	0	0	-1	-1	-1	-1	-1	-1	-1	-1	-1	0	
Sac River @ Rio Vista	0	0	0	0	0	0	0	0	0	0	0	0	
SJ River @ Antioch	0	0	0	0	0	0	0	0	0	0	0	0	
Predation	0	0	-1	-1	-1	-1	-1	-1	-1	-1	-1	0	-9
Food supply	1	1	1	1	1	2	2	2	1	1	1	1	15
Shallow/ nearshore habitat	0	0	0	0	1	1	1	1	1	0	0	0	5
Salinity/X2	0	0	0	0	0	0	0	0	0	-1	-1	-1	-3
Agricultural diversions	1	1	1	1	1	1	1	2	2	2	2	1	16
Total	2	2	-4	-5	-8	-6	-6	-10	-7	-12	-8	1	-9

Diversion Effects on Delta Smelt: Alternative 1 DRY YEARS

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Total
Entrainment	0	0	-2	-2	-2	-3	-2	-3	-3	-3	-2	0	-22
Entrainment (export)	0	0	-2	-2	-2	-2	-2	-3	-3	-3	-2	0	
CCF predation	0	0	-1	-1	-1	-2	-2	-3	-3	-3	-2	0	
Handling	0	0	-1	-1	-1	-2	-2	-3	-3	-3	-2	0	
Hydrodynamics	0	0	-2	-2	-2	-3	-2	-3	-3	-3	-2	0	-22
Cross -Delta Flow	0	0	-1	-1	-1	-2	-2	-3	-3	-3	-2	0	
Qwest	0	0	-1	-1	-1	-2	-2	-3	-3	-3	-2	0	
Old River @Bacon Island	0	0	-1	-1	-1	-2	-2	-3	-3	-3	-2	0	
Sac River @ Rio Vista	0	0	0	0	0	0	-1	-2	-2	-2	-1	0	
SJ River @ Antioch	0	0	-2	-2	-1	-1	-1	-2	-2	-2	-1	0	
Predation	0	0	-1	-1	-1	-1	-2	-2	-2	-2	-2	0	-14
Food supply	1	0	-1	-1	-1	-1	-1	-1	-1	-1	-1	0	-8
Shallow/ nearshore habitat	0	0	0	0	1	1	1	1	0	0	0	0	4
Salinity/X2	-1	-1	0	0	1	1	1	-1	-1	-1	-1	-1	-4
Agricultural diversions	1	1	1	1	1	1	1	2	2	2	2	1	16
Total	1	0	-14	-14	-11	-18	-18	-29	-30	-30	-20	0	-50

Diversion Effects on Delta Smelt: Alternative 2 WET YEARS

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Total
Entrainment	0	0	-2	-2	-2	-2	-2	-3	-2	-3	-2	0	-20
Entrainment (export)	0	0	-1	-1	-1	-1	-2	-3	-2	-1	-1	0	
CCF predation	0	0	-1	-1	-2	-2	-2	-3	-2	-2	-1	0	
Handling	0	0	0	0	-1	-1	-1	-2	-2	-1	0	0	
Hydrodynamics	0	0	-2	-2	-2	-2	-2	-3	-2	-3	-2	0	-20
Cross -Delta Flow	0	0	-2	-2	-2	-2	-2	-2	-2	-2	-2	0	
Qwest	0	0	0	0	0	0	0	0	0	0	0	0	
Old River @Bacon Island	0	0	-1	-2	-2	-2	-2	-2	-1	-1	-1	0	
Sac River @ Rio Vista	0	0	0	0	0	0	0	0	0	0	0	0	
SJ River @ Antioch	0	0	0	0	0	0	0	0	0	0	0	0	
Predation	0	0	-1	-1	-1	-1	-1	-1	-1	-1	-1	0	-9
Food supply	1	1	1	1	1	2	2	2	1	1	1	1	15
Shallow/ nearshore habitat	0	0	0	0	0	0	0	0	0	0	0	0	0
Salinity/X2	0	0	0	0	0	0	0	0	0	-1	-1	-1	-3
Agricultural diversions	1	1	1	1	1	1	1	2	2	2	2	1	16
Total	2	2	-8	-9	-11	-10	-11	-15	-11	-12	-8	1	-21

Diversion Effects on Delta Smelt: Alternative 2 DRY YEARS

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Total
Entrainment	0	0	-3	-3	-3	-3	-3	-3	-3	-3	-2	0	-26
Entrainment (export)	0	0	-1	-1	-1	-1	-2	-3	-3	-3	-2	0	
CCF predation	0	0	-1	-1	-2	-2	-2	-3	-3	-3	-2	0	
Handling	0	0	-1	-1	-1	-2	-2	-3	-3	-3	-2	0	
Hydrodynamics	0	0	-3	-3	-3	-3	-3	-3	-3	-3	-2	0	-26
Cross -Delta Flow	0	0	-2	-2	-2	-2	-2	-3	-3	-3	-2	0	
Qwest	0	0	0	0	0	0	0	0	-1	-1	-1	0	
Old River @Bacon Island	0	0	-1	-2	-2	-2	-2	-3	-3	-3	-2	0	
Sac River @ Rio Vista	0	0	-2	-2	-2	-2	-1	-1	-2	-2	-1	0	
SJ River @ Antioch	0	0	0	0	0	0	0	0	0	0	0	0	
Predation	0	0	-1	-1	-1	-2	-2	-2	-2	-2	-2	0	-15
Food supply	1	0	-1	-1	-1	-1	-1	-1	-1	-1	-1	0	-8
Shallow/ nearshore habitat	0	0	0	0	-1	-1	-1	-1	0	0	0	0	-4
Salinity/X2	-1	-1	0	0	1	1	1	-1	-1	-1	-1	-1	-4
Agricultural diversions	1	1	1	1	1	1	1	2	2	2	2	1	16
Total	1	0	-15	-16	-17	-19	-19	-25	-26	-26	-18	0	-67

Diversion Effects on Delta Smelt: Alternative 3 WET YEARS

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Total
Entrainment	0	0	1	1	1	1	2	2	1	1	1	0	11
Entrainment (export)	0	0	1	1	1	1	2	2	1	1	1	0	
CCF predation	0	0	1	1	1	1	2	2	1	1	1	0	
Handling	0	0	0	0	0	0	-1	-2	-1	-1	0	0	
Hydrodynamics	0	0	1	2	2	2	2	2	1	1	1	0	14
Cross -Delta Flow	0	0	0	0	0	0	0	0	0	0	0	0	
Qwest	0	0	0	0	0	0	0	0	0	0	0	0	
Old River @Bacon Island	0	0	1	1	1	1	1	1	1	1	1	0	
Sac River @ Rio Vista	0	0	0	0	0	0	0	0	0	0	0	0	
SJ River @ Antioch	0	0	1	1	1	1	1	1	1	1	1	0	
Predation	0	0	0	0	0	0	0	0	0	0	0	0	0
Food supply	1	1	1	1	1	2	2	2	1	1	1	1	15
Shallow/ nearshore habitat	0	0	1	1	2	2	2	2	2	1	1	0	14
Salinity/X2	0	0	0	0	0	0	0	0	0	-1	-1	-1	-3
Agricultural diversions	1	1	1	1	1	1	1	2	2	2	2	1	16
Total	2	2	9	10	11	12	14	14	10	8	9	1	67

Diversion Effects on Delta Smelt: Alternative 3 DRY YEARS

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Total
Entrainment	0	0	1	1	2	2	2	3	2	2	1	1	17
Entrainment (export)	0	0	1	1	2	2	2	3	2	2	1	1	
CCF predation	0	0	1	1	2	2	2	3	2	2	1	1	
Handling	0	0	0	0	0	-1	-1	-2	-2	-2	-1	0	
Hydrodynamics	0	0	0	0	1	1	1	1	1	1	1	0	7
Cross -Delta Flow	0	0	0	0	0	0	0	0	0	1	1	0	
Qwest	0	0	0	0	0	0	0	0	0	0	0	0	
Old River @Bacon Island	0	0	0	0	1	1	1	1	1	0	0	0	
Sac River @ Rio Vista	0	0	-1	-1	-1	-1	-1	0	-1	0	0	0	
SJ River @ Antioch	0	0	1	1	1	1	1	1	1	1	1	0	
Predation	0	0	0	0	0	1	1	1	1	1	0	0	5
Food supply	1	0	-1	-1	-1	-1	-1	-1	-1	-1	-1	0	-8
Shallow/ nearshore habitat	0	0	1	1	2	2	2	2	1	1	1	0	13
Salinity/X2	-1	-1	0	0	1	1	1	-1	-1	0	0	-1	-2
Agricultural diversions	1	1	1	1	1	1	1	2	2	2	2	1	16
Total	1	0	4	4	11	11	11	13	8	10	7	3	48

Net Effects Matrices with Common Programs included
No Action Conditions - Existing
WET YEARS

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Total
Entrainment	0	0	0	0	-1	-1	0	0	0	-1	-1	0	-4
Hydrodynamics	0	0	0	0	-1	-1	0	-1	-1	-1	-1	0	-6
Predation	0	0	0	0	0	0	0	0	0	0	0	0	0
Food supply	0	0	0	0	0	0	0	0	0	0	0	0	0
Shallow/ nearshore habitat	0	0	0	0	0	0	0	0	0	0	0	0	0
Salinity/X2	0	0	0	0	0	0	0	0	0	0	0	0	0
Agricultural diversions	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	0	0	0	0	-2	-2	0	-1	-1	-2	-2	0	-10

Net Effects Matrices with Common Programs included
No Action Conditions - Existing
DRY YEARS

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Total
Entrainment	0	0	-1	-1	-1	-1	0	0	0	0	0	0	-4
Hydrodynamics	0	0	-1	-1	-1	-1	0	0	0	0	0	0	-4
Predation	0	0	0	0	0	0	0	0	0	0	0	0	0
Food supply	0	0	-1	-1	0	0	0	0	0	0	0	0	-2
Shallow/ nearshore habitat	0	0	0	0	0	0	0	0	0	0	0	0	0
Salinity/X2	0	0	0	0	0	0	0	0	0	0	0	0	0
Agricultural diversions	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	0	0	-3	-3	-2	-2	0	0	0	0	0	0	-10

Net Effects Matrices with Common Programs included
Common Programs - Existing
WET YEARS

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Total
Entrainment	0	0	0	0	0	0	0	0	0	0	0	0	0
Hydrodynamics	0	0	0	0	0	0	0	0	0	0	0	0	0
Predation	0	0	0	0	0	0	0	0	0	0	0	0	0
Food supply	1	1	1	1	1	2	2	2	1	1	1	1	15
Shallow/ nearshore habitat	0	0	1	1	2	2	2	2	1	0	0	0	11
Salinity/X2	0	0	0	0	0	0	0	0	0	0	0	0	0
Agricultural diversions	1	1	1	1	1	1	1	3	4	4	4	1	23
Total	2	2	3	3	4	5	5	7	6	5	5	2	49

Net Effects Matrices with Common Programs included
Common Programs - Existing
DRY YEARS

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Total
Entrainment	0	0	0	0	0	0	0	0	0	0	0	0	0
Hydrodynamics	0	0	0	0	0	0	0	0	0	0	0	0	0
Predation	0	0	0	0	0	0	0	0	0	0	0	0	0
Food supply	1	1	1	1	1	2	2	2	2	2	1	1	17
Shallow/ nearshore habitat	0	0	1	1	2	2	2	2	0	0	0	0	10
Salinity/X2	0	0	0	0	0	0	0	0	0	0	0	0	0
Agricultural diversions	1	1	1	1	1	1	3	4	5	5	4	1	28
Total	2	2	3	3	4	5	7	8	7	7	5	2	55

Net Effects Matrices with Common Programs included
Alternative 1 - Existing — **WET YEARS**

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Total
Entrainment	0	-0	0	0	-1	-1	0	0	0	-1	-1	0	-4
Hydrodynamics	0	0	0	0	-1	-1	0	-1	-1	-1	-1	0	-6
Predation	0	0	0	0	0	0	0	0	0	0	0	0	0
Food supply	1	1	1	1	1	2	2	2	1	1	1	1	15
Shallow/ nearshore habitat	0	0	1	1	2	2	2	2	1	0	0	0	11
Salinity/X2	0	0	0	0	0	0	0	0	0	0	0	0	0
Agricultural diversions	1	1	1	1	1	1	1	3	4	4	4	1	23
Total	2	2	3	3	2	3	5	6	5	3	3	2	39

Net Effects Matrices with Common Programs included
Alternative 1 - Existing — **DRY YEARS**

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Total
Entrainment	0	0	-1	-1	-1	-1	0	0	0	0	0	0	-4
Hydrodynamics	0	0	-1	-1	-1	-1	0	0	0	0	0	0	-4
Predation	0	0	0	0	0	0	0	0	0	0	0	0	0
Food supply	1	1	0	0	1	2	2	2	2	2	1	1	15
Shallow/ nearshore habitat	0	0	1	1	2	2	2	2	0	0	0	0	10
Salinity/X2	0	0	0	0	0	0	0	0	0	0	0	0	0
Agricultural diversions	1	1	1	1	1	1	3	4	5	5	4	1	28
Total	2	2	0	0	2	3	7	8	7	7	5	2	45

Net Effects Matrices with Common Programs included
Alternative 2 - Existing — **WET YEARS**

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Total
Entrainment	0	0	-1	-1	-1	-1	0	0	0	-1	-1	0	-6
Hydrodynamics	0	0	-1	-1	-1	-1	-1	-2	-1	-2	-1	0	-11
Predation	0	0	0	0	0	0	0	0	0	0	0	0	0
Food supply	1	1	1	1	1	2	2	2	1	1	1	1	15
Shallow/ nearshore habitat	0	0	1	1	1	1	1	1	0	0	0	0	6
Salinity/X2	0	0	0	0	0	0	0	0	0	0	0	0	0
Agricultural diversions	1	1	1	1	1	1	1	3	4	4	4	1	23
Total	2	2	1	1	1	2	3	4	4	2	3	2	27

Net Effects Matrices with Common Programs included
Alternative 2 - Existing — **DRY YEARS**

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Total
Entrainment	0	0	-2	-2	-2	-1	-1	0	0	0	0	0	-8
Hydrodynamics	0	0	-2	-2	-2	-1	-1	0	0	0	0	0	-8
Predation	0	0	0	0	0	-1	0	0	0	0	0	0	-1
Food supply	1	1	0	0	1	2	2	2	2	2	1	1	15
Shallow/ nearshore habitat	0	0	1	1	0	0	0	0	0	0	0	0	2
Salinity/X2	0	0	0	0	0	0	0	0	0	0	0	0	0
Agricultural diversions	1	1	1	1	1	1	3	4	5	5	4	1	28
Total	2	2	-2	-2	-2	0	3	6	7	7	5	2	28

Net Effects Matrices with Common Programs included
Alternative 3 - Existing — **WET YEARS**

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Total
Entrainment	0	0	2	2	2	2	4	5	3	3	2	0	25
Hydrodynamics	0	0	2	3	3	3	3	3	2	2	2	0	23
Predation	0	0	1	1	1	1	1	1	1	1	1	0	9
Food supply	1	1	1	1	1	2	2	2	1	1	1	1	15
Shallow/ nearshore habitat	0	0	2	2	3	3	3	3	2	1	1	0	20
Salinity/X2	0	0	0	0	0	0	0	0	0	0	0	0	0
Agricultural diversions	1	1	1	1	1	1	1	3	4	4	4	1	23
Total	2	2	9	10	11	12	14	17	13	12	11	2	115

Net Effects Matrices with Common Programs included
Alternative 3 - Existing — **DRY YEARS**

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	
Entrainment	0	0	2	2	3	4	4	6	5	5	3	1	35
Hydrodynamics	0	0	1	1	2	3	3	4	4	4	3	0	25
Predation	0	0	1	1	1	2	3	3	3	3	2	0	19
Food supply	1	1	0	0	1	2	2	2	2	2	1	1	15
Shallow/ nearshore habitat	0	0	2	2	3	3	3	3	1	1	1	0	19
Salinity/X2	0	0	0	0	0	0	0	0	0	1	1	0	2
Agricultural diversions	1	1	1	1	1	1	3	4	5	5	4	1	28
Total	2	2	7	7	11	15	18	22	20	21	15	3	143

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Alternative Matrices WITHOUT Common Programs
Alternative 1 - Common Programs — WET YEARS

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Total
Entrainment	0	0	0	0	-1	-1	0	0	0	-1	-1	0	-4
Hydrodynamics	0	0	0	0	-1	-1	0	-1	-1	-1	-1	0	-6
Predation	0	0	0	0	0	0	0	0	0	0	0	0	0
Food supply	0	0	0	0	0	0	0	0	0	0	0	0	0
Shallow/ nearshore habitat	0	0	0	0	0	0	0	0	0	0	0	0	0
Salinity/X2	0	0	0	0	0	0	0	0	0	0	0	0	0
Agricultural diversions	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	0	0	0	0	-2	-2	0	-1	-1	-2	-2	0	-10

Alternative Matrices WITHOUT Common Programs
Alternative 1 - Common Programs — DRY YEARS

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Total
Entrainment	0	0	-1	-1	-1	-1	0	0	0	0	0	0	-4
Hydrodynamics	0	0	-1	-1	-1	-1	0	0	0	0	0	0	-4
Predation	0	0	0	0	0	0	0	0	0	0	0	0	0
Food supply	0	0	-1	-1	0	0	0	0	0	0	0	0	-2
Shallow/ nearshore habitat	0	0	0	0	0	0	0	0	0	0	0	0	0
Salinity/X2	0	0	0	0	0	0	0	0	0	0	0	0	0
Agricultural diversions	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	0	0	-3	-3	-2	-2	0	0	0	0	0	0	-10

Alternative Matrices WITHOUT Common Programs
Alternative 2 - Common Programs — WET YEARS

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Totals
Entrainment	0	0	-1	-1	-1	-1	0	0	0	-1	-1	0	-6
Hydrodynamics	0	0	-1	-1	-1	-1	-1	-2	-1	-2	-1	0	-11
Predation	0	0	0	0	0	0	0	0	0	0	0	0	0
Food supply	0	0	0	0	0	0	0	0	0	0	0	0	0
Shallow/ nearshore habitat	0	0	0	0	-1	-1	-1	-1	-1	0	0	0	-5
Salinity/X2	0	0	0	0	0	0	0	0	0	0	0	0	0
Agricultural diversions	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	0	0	-2	-2	-3	-3	-2	-3	-2	-3	-2	0	-22

Alternative Matrices WITHOUT Common Programs
Alternative 2 - Common Programs — DRY YEARS

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Totals
Entrainment	0	0	-2	-2	-2	-1	-1	0	0	0	0	0	-8
Hydrodynamics	0	0	-2	-2	-2	-1	-1	0	0	0	0	0	-8
Predation	0	0	0	0	0	-1	0	0	0	0	0	0	-1
Food supply	0	0	-1	-1	0	0	0	0	0	0	0	0	-2
Shallow/ nearshore habitat	0	0	0	0	-2	-2	-2	-2	0	0	0	0	-8
Salinity/X2	0	0	0	0	0	0	0	0	0	0	0	0	0
Agricultural diversions	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	0	0	-5	-5	-6	-5	-4	-2	0	0	0	0	-27

Alternative Matrices WITHOUT Common Programs
Alternative 3 - Common Programs — WET YEARS

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Total
Entrainment	0	0	2	2	2	2	4	5	3	3	2	0	25
Hydrodynamics	0	0	2	3	3	3	3	3	2	2	2	0	23
Predation	0	0	1	1	1	1	1	1	1	1	1	0	9
Food supply	0	0	0	0	0	0	0	0	0	0	0	0	0
Shallow/ nearshore habitat	0	0	1	1	1	1	1	1	1	1	1	0	9
Salinity/X2	0	0	0	0	0	0	0	0	0	0	0	0	0
Agricultural diversions	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	0	0	6	7	7	7	9	10	7	7	6	0	66

Alternative Matrices WITHOUT Common Programs
Alternative 3 - Common Programs — DRY YEARS

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Total
Entrainment	0	0	2	2	3	4	4	6	5	5	3	1	35
Hydrodynamics	0	0	1	1	2	3	3	4	4	4	3	0	25
Predation	0	0	1	1	1	2	3	3	3	3	2	0	19
Food supply	0	0	-1	-1	0	0	0	0	0	0	0	0	-2
Shallow/ nearshore habitat	0	0	1	1	1	1	1	1	1	1	1	0	9
Salinity/X2	0	0	0	0	0	0	0	0	0	1	1	0	2
Agricultural diversions	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	0	0	4	4	7	10	11	14	13	14	10	1	88

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CALFED BAY-DELTA PROGRAM

CALFED Bay-Delta Program
Revised Draft EIS/R Completion Schedule

DRAFT
7/9/98

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Management Team		<u>May 21</u>
		• Nature of Decision
		• Bromide Status Report
		• Response to Comments - EIS/R
		• Proposed Level of Detail
		  • Water Quality
		  • Storage
		  • Water Use Efficiency
		  • Watershed Management
		  • Water Transfers
			<u>July 1</u>
			• Preferred Alternative Framework
			• Fish Diversion Effects Draft Report
			• ERP Update
			• Conservation Strategy
			• Seismic Vulnerability of Levees
			• Agency Review Team (ART) Issues
				<u>July 30</u>
				• Preferred Alternative Staging/Linkages, Assurances, Finances
				• Storage and Conveyance Update
				• Water Use Efficiency Update
				• Water Transfer Policy White Paper
				• Fish Diversion Effects Update
				• ART Issues
					<u>September 1</u>
					• Preferred Alternative Staging/Linkages, Assurances, Finances
					• Fish Diversion Effects Report
					• Draft Program Implementation Plan
					• Bromides Report from Expert Panel
					• Restoration Coordination/Project Selection Update
						<u>October 1</u>
						• Draft Phase II Report (includes Revised Draft Program Implementa-tion Plan, staging, linkages, financing, assurances)
							<u>October 26</u>
							• Revised Draft EIS/R
							• Revised Phase II Report
								<u>November 23</u>
								•

Policy Group 2-Day Meetings	<u>May 1</u>
	• Fish Diversion Effects
	• Drinking Water Quality (Bromides)
	• Agricultural Water Use Efficiency
	• Staging and Linkage Program
	• Nature of Decision
	• Financial Strategy
		<u>June 4-5</u>
		• Nature of Decision
		• Bromide Status Report
		• Program Updates
		  • Water Quality
		  • Storage
		  • Water Transfers
		  • Levees
			<u>July 14-15</u>
			• Preferred Alternative Framework
			• Fish Diversion Effects Draft Report
			• ERP Update
			• Conservation Strategy
			• Seismic Vulnerability of Levees
			• ART Issues
				<u>August 13-14</u>
				• Identify Preferred Alternative, Staging/ Linkages, Assurances, Finances
				• Storage and Conveyance Update
				• Water Use Efficiency Update
				• Water Transfer Policy White Paper
				• ART Issues
				• Fish Diversion Effects Update
					<u>September 14-15</u>
					• Preferred Alternative Staging/Linkages, Assurances, Finances
					• Fish Diversion Effects Report
					• Draft Program Implementation Plan
					• Bromides Report from Expert Panel
					• Restoration Coordination/Project Selection
						<u>October 15-16</u>
						• Draft Phase II Report (includes Revised Draft Program Implementa-tion Plan, staging, linkages, financing, assurances)
							<u>November 9-10</u>
							• Revised Draft EIS/R
							• Phase II Report
								<u>December 17-18</u>
								•

BDAC	<u>May 14 - Redding</u> • Staging and Linkage Program • Northern California Issues • Watershed Management Strategy	<u>June 17-18 - Fresno</u> • Nature of Decision • Water Use Efficiency • Draft Program Implementation Plan • San Joaquin Valley Interests of Concern • Water Transfers	<u>July 16 - Bay Area</u> • Preferred Alternative Framework • Fish Diversion Effects Draft Report • CALFED Outreach and the Business Community • Seismic Vulnerability of Levees • State of Bay and Environment Panel		<u>September 10</u> • Preferred Program Alternative - Staging/Linkages • Fish Diversion Effects Report • Bromides • Restoration Coordination Project Selection • Water Use Efficiency • Delta Land Use Conversion Issue • Seismic Vulnerability of Levees	<u>October 29</u> • Phase II Report (includes Implementa-tion Plan, staging, linkages, financing, assurances) • Levee Integrity Program		<u>December 10</u> • Revised Draft EIS/R • Phase II Report

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